CHEMISTRY HONOURS SYLLABUS

Paper No	Name of Paper	Credits	Marks
CHE-UG-E101	Introduction to Chemistry I	4	100
CHE-UG-E201	Introduction to Chemistry II	4	100
CHE-UG-E301	Introduction to Chemistry III	4	100
CHE-UG-C401	Organic Chemistry	4	100
CHE-UG-C402	Inorganic Chemistry	4	100
CHE-UG-C501	Physical Chemistry	4	100
CHE-UG-C502	Spectroscopy	4	100
CHE-UG-C601	Instrumental Techniques	4	100
CHE-UG-C602	Bio and Medicinal Chemistry	4	100
TOTAL		**36**	**900**

CHE-UG-E101: Introduction to Chemistry I

Unit I: Inorganic Chemistry

Atomic Structure:

Brief discussion: Bohr's theory and five series of hydrogen spectrum, Fine spectra: Relativistic correction and Sommerfield theory, Quantum numbers, space quantization Zeeman Effect / Stark effect. Shape of atomic orbital: Schrödinger's wave equation, Significance of Ψ and $|\Psi^* \Psi|$, radial and angular wave functions, Probability distribution curves of s, p, d orbital.

Periodic Table and properties: s, p, d and f block elements, noble gases, electronic structure, oxidation states, atomic covalent ionic and van der Waal radii, variation of size of the atoms, ionization energy, electronegativity, electropositive character, electron affinity, inert pair effect and diagonal relationship.

Chemical Bonding-I:

Radius ratio / coordination number/ limitation of radius ratio; potential energy diagram for the formation of ionic bond; lattice energy Born-Lande equation , Born Haber Cycle; solvation energy and solubility of ionic solids.

Unit II: Organic Chemistry

Chemistry of Alkanes, alkenes and alkynes -Structure, Reactivity, Hybridization. Functional Groups. Concepts of Isomerism – Constitutional Isomerism. Inductive effect, Mesomeric effect Hyperconjugation, Resonance, steric effect, thermodynamically controlled and kinetically controlled products. Substitution (SN1, SN2), Elimination (E1, E2), addition reactions: C=C and C=O, Rearrangments, Reactive intermediates: carbocation, carbanion, carbene, nitrene, free radicals (general idea and reactions)

Unit III: Physical Chemistry

Gaseous States: Kinetic theory of gases: Assumption of Kinetic theory of gases,Root mean square, average and most probable velocities; Maxwell's distribution of molecular velocities;

collision number, collision diameter and mean free path. Real gases**:** Causes of deviation from ideal behavior; equations of states for real gases (vanderwaals) critical constants; Boyle temp and Andrew equation, continuity of state; law of corresponding states; reduced equation of state.

Solids: Elementary discussion on the basic concept of crystallography with special reference to space lattice, unit cell, X-ray diffraction by crystals, Bragg's equation; close packing in crystals, bravais lattice.crystal structure of NaCl , KCl, CsCl, ZnS. Crystal defects.

Thermodynamics: System, surroundings; types of systems, intensive and extensive properties; state and path functions and their differentials; thermodynamic processes; concept of heat and work. First law of thermodynamics, internal energy and enthalpy; heat capacity, relation between heat temperature relation between Cp and Cv; isothermal and Adiabatic changes; enthalpy of chemical changes; temperature dependence of enthalpy, inversion temp.Joule Thompson effect

Unit IV: Organic Chemistry Practical

Qualitative analysis of organic compounds (element detection and functional groups), melting point determination.

CHE-UG-E201: Introduction to Chemistry II

Unit I: Inorganic Chemistry

Chemical Bonding-II: Concept of bonding, σ and π bonds, Valence Bond Theory-basic postulates. Hybridization and types of hybrid orbital; VSEPR theory and shapes of molecules; Molecular Orbital Theory basic postulates; difference between VBT and MOT. M.O. diagrams of homonuclear diatomic molecules up to Ne, CO and NO; coordinate bond; hydrogen bond; van der Waals forces. Brief discussion on metallic bonding.

Chemistry of Elements:- Reactions and properties of Group I to IV. Reactivity of the elements of periodic table with special reference to diagonal relationship, allotropy, catenation, complex formation, lanthanide contraction.Compounds of noble gases (Xenon)

Acids and Bases: Arrhenius theory, Bronsted and Lowry theory, Lux flood concept, Lewis concept, HSAB concept.

Unit II: Organic Chemistry

Alcohols: Preparation and properties of primary, secondary and tertiary alcohols, distinction of alcohols by Victor Meyer and oxidation method. Conversions of hydroxyl groups to other functional groups.

Aldehyde & Ketone: General methods of preparation of aldehydes and ketones: mechanisms of nucleophilic addition (1,2 and 1,4 etc.) addition, condensation reactions, Aldol condensation, Cannizzaro, haloform, benzoin, ReimerTiemann, Perkin reactions. Aromatic compounds: Resonance; Huckels rule, antiaromaticity; eletrophilic and nucleophilic substitutions reactions. Friedel Crafts reactions (alkylation and acylation) directive effect of substituents in benzene.

Unit III: Physical Chemistry

Thermodynamics-II: Second law of thermodynamics, Carnot cycle, Refrigeration, entropy, spontaneity of a process, Gibbs free energy; Third law of thermodynamics, Nernst heat theorem.
Chemical Equilibrium and Phase Rule: Equilibrium constant & their relationship, and free energy, thermodynamic derivation of law of mass action; Le Chatelier's principle and its applications. Study of a decomposition of PCl5 & synthesis of Ammonia.(Haber's Prcoess) Clausius-Clapeyron equation.Statement of phase rule and meaning of the terms- phase, component and degree of freedom; phase equilibrium of one component system-water and S systems.
Chemical Kinetics and Catalysis: Order and molecularity, integrated rate lawsfor zero, first and second order reactions; pseudo first order reaction; determination of the order of a reaction; effect of temperature on reaction rate and activation energy (concept only). Catalysis, characteristic of catalyzed reactions; classification of catalysis; miscellaneous examples.
Photochemistry: Interaction of radiation with matter; difference between thermal and photochemical processes; laws of photochemistry: Grothus-Drapper law, Stark-Einstein law; fluroscence and phosphorescence;

Unit IV: Inorganic Chemistry Practical

1. Qualitative inorganic analysis mixed salts (with three ions) including interfering acid radicals. Quantitative inorganic analysis.
2. Redox titration
3. Iodometric titration.

CHE-UG-E301: Introduction to Chemistry III

Unit I: Inorganic Chemistry

Coordination Chemistry: Nomenclature; classification of ligands and their nature; Double salt, Werner's theory, EAN rule, isomerism and types; valence bond theory and Crystal Field Theory (octahedral and Tetrahedral complexes); high-spin low spin complexes and calculation of CFSE. spectral and magnetic properties.
Radioactivity and Nuclear Chemistry: Natural and artificial radioactivity: Radioactive series; Law of radioactive decay, half life, average life; radioactive equilibrium : measurement of radioactivity, stability of atomic nucleus : n/p ratio; Meson Field theory, mass defect: binding energy : packing fraction; Nuclear Transmutation nuclear reactions; artificial radioactivity and nuclear isomerism; fission, fusion; application of radioisotopes, radiocarbon dating, nuclear reactors; radiation hazards.
Analytical Chemistry: Statistical methods of analysis and data validation: Mean, Median Mode, Standard deviation. Errors and calculation of errors. Principles of Acid-Base and Redox titrations and Iodometric titration with examples.

Unit II: Organic Chemistry

Amines: primary, secondary and tertiary; methods of separation of amines (Hinsberg method); methods of preparation of primary amine-Hoffmann hypobromide, Schmidts and Curtius reactions. Aromatic amines: Preparation and properties; diazonium salts and their

reactions, preparation of diazomethane and comparison of its stability with aromatic diazonuim compounds, uses.

Optical isomerism: Introduction of symmetry elements and operations. Chiral centres, optical isomerism of lactic and tartaric acids. Geometrical isomerism (maleic and fumaric acids). Enantiomers, Diastereomers,

Carbohydrates: Definition, classification; reactions and determination of structures of glucose and fructose; mutarotation, inversion of cane sugar.

Unit III: Physical Chemistry

Solutions: Surface tension and viscosity, temperature dependence of surface tension and viscosity; dipole moment, structure determination from dipole moment analysis. Raoult's law ideal and non ideal solutions; dilute solution, colligative properties, Vant Hoff's factor.

Ionic Equilibrium: Conductance of solutions; weak and strong electrolytes, Ostwald's dilution law, its uses and limitations; DebyeHuchel theory, onsager theory transport number; applications of conductometric titrations.

Electrochemical Cells: Reversible and irreversible cells; types of reversible electrodes, cell construction and sign convention electrode reactions. Nernst equation; derivation of cell E.M.F. and single electrode potential; standard hydrogen electrode, reference electrode, standard electrode potential. Solubility products and activity coefficient; common ion effect; ionic product of water, pH, hydrolysis of salts; buffer solutions (only significance, no derivations), Handerson equation, concept of indicator.Introduction to corrosion.

Surface Chemistry: Types of adsorption, Freundlich and Langmuir adsorption isotherm;BET equation, change in enthalpy, entropy and free energy of adsorption. Definition, classification, preparation, purification and stability of colloids, kinetic, optical and electrical properties of colloids, protective action, Hardy-Schulze law, Gold number, Emulsions, types of emulsions, preparation, emulsifiers.

Unit III: Physical Chemistry Practical

1. Viscosity and surface tension measurements of aqueous solutions.
2. Verification of Lambert Beer's law for methyl orange and phenolphthalein at different Concentrations.
3. Conductometric titration of different combination of strong and weak acids and bases.
4. Preparation of a set of buffer solutions and to find the pH of the unknown solution colorimetrically.

CHE-UG-C401: Organic Chemistry

Unit I: Photochemistry of Organic Compounds

General concepts, Franck- Condon principle; singlet, triplet states; Norrish type I and II processes, Paterno-Buchi reaction, Barton reaction, photo-oxidation and reduction, rearrangements.

Pericyclic Reactions: Phase, symmetry. MO theory, bonding, anti-bonding and non-bonding MO'S, Electro-cyclic, sigmatropic reactions,conrotation,disrotation,cycloaddition reactions, Diels- Alder reaction, supra and interfacial. Claisen rearrangement.

Unit II: Heterocyclic Compounds

General idea; methods of preparations, properties and reactions of furan, pyrole, pyridine, indole, quinoline, isoquinoline; Fisher-Indole synthesis, Skraup synthesis, Bischler-Napiereski reaction.

Stereochemistry Chirality of molecules, stereoisomers, notations, d, l, R, S systems, E, Z systems, conformational analysis of n-butane, 1,2-ethane diol, energy profile curves including that of thedihedral angle, eclipse, staggered, gauch conformations; representations by Newmann, Sawhorse, Fischer projection; chirality of allene and biphenyl systems (atropisomerism). Conformation of cyclohexane and substituted cyclohexane.

Unit III: Use of Reagents in Organic Synthesis

OsO_4, SeO_2, $Ph(OAc)_4$, HIO_4, NBS, B_2H_6, $NaBH_4$, 9-BBN, CrO_3, $LiAlH_4$, n-ButylyLithium, MCPBA, Na in liquid Ammonia including mechanism.

Unit IV: Organic Chemistry Practical

1. Identification of solid organic compounds (functional groups, preparations of derivatives and melting points/boiling points). At least 6 sample in each case.
2. Determination of Rf values and identification of organic Compounds (Separation of two/three compounds by TLC/Paper chromatography.)
3. Detection of functional group using IR and UV-Visible spectroscopy.

CHE-UG-C402: Inorganic Chemistry

Unit I: Elemental Chemistry

Group III: Preparation, properties and structures of Borane carboranes, borax, borazine.

Group IV: Lamellar compounds, metal carbonyls; fullerenes, carbides, flurocarbons, silicates (structure), silicones.

Group V: Study of Hydrides (stability/basic character/bond and angles) hydrazine, Phosphorus and Hypophosphorus acids ,Phosphonitriles, Soduim nitro prussides(preaparation,properties and uses) and oxyacids of P, phosphonitrles

Group VI: oxides, peroxides, superoxides, hydrides of S (acid character and bond angles), oxides of S, acids and oxyacids of S(Sulphuric acid and sulphorous acid; thionic acids.

Group VII: Anamolous behaviour of F, basic character of halogens, acids and oxy acids; oxidisingproperty; inter halogens, polyhalides and Pseudohalides.

Unit II: Oxidation and Reduction

Use of redox potential data, Analysis of redox cycle redox stability in water, Frost Latimer and Pourbaix diagrams, Principles involved in the extraction of elements (by the use of redox potential).

Coordination Chemistry (II): Limitations of VBT and introduction to Crystal Field Theory, Splitting of d-orbitals in octahedral, tetrahedral and square planer field. tetragonal distortion factors affecting crystal field parameters , Crystal Field stabilization energy, magnetic property, L-S coupling, μ and μ_{eff} calculation, term symbols, "d-d spectra" and introduction to selection,

Orgel diagram of d^1 and d^9 system. Discussion on the electronic spectra of $[Ti(H20)6]^{3+}$,$[Ni(H20)6]^{2+}$. Thermodynamic stability of metal complex and factor affecting the stability.

Unit III: Non Aqueous Solvents

Physical characteristics of solvents; types of solvents and general characteristics, Reaction in non aqueous solvents with special reference to liq. HF, liq. NH3and liq. SO2.

Organometallic Chemistry Definition, types of ligands, nomenclature and classification, σ-bonded compounds,structure & bonding in metallocennes and dibenzene chromium, π- Bonded compounds,Strucrure & bonding in metallocenes 7dibenzene chromium, Carbonyls 18 electron rule, monomeric and dimeric carbonyls,

Lanthanides and Actinides: General features- electronic structure, oxidation states, ionic radii, Lanthanide contraction &consequences Occurrence and isolation of lanthanides Solvent extraction of Np, Pu and Am from U.

Unit IV: Practical

1. Qualitative analysis mixtures containing four radicals containing rare earths.
2. Quantitative analysis and estimation ions containing two radicals: Fe/Cu, Fe/Cr, Fe/ Ca, Ba/Ca.
3. Gravimetric analysis.

CHE-UG-501: Physical Chemistry

Unit I: Quantum Mechanics

Postulates, operators, Schrödinger wave equation and its applications, particle in a box (rigorous treatment), energy levels, wave function, probability distribution function, nodal properties, degeneracy, qualitative treatment of (i) rigid rotor (ii)harmonic oscillator (iii)Hydrogen atom (iv) Electron Spin (iv) multi electron system.

Chemical Bonding: Covalent bonding, statement of variation theorem, valence bond and molecular orbital approach, LCAO-MO treatment of H_2^+ and He_2^+ VBT approach of H_2 molecule, localised and de localized, M.O's of homolnuclear, heteronuclear diatomic and triatomic molecules (eg. BeH2, H2O and CO2).

Unit II: Polymers

Introduction to synthetic polymers, types of polymers, isotactic, sydiotactic polymers, attactic polymers, thermoplastic and thermosetting polymers. Polymerization reactions, addition, condensation polymers, mechanism of addition, polymerization reactions, free radical cationic and anionic and Zieglar Natta catalyst. Vinyl polymers, methods of vinyl polymerization PVC, PVA, polystyrene and Teflon; natural and synthetic polymers.

Solid State: Nature of solid state, law of constancy of interracial angles, law of rational indices, miller indices, symmetry and symmetry elements, symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen bravais lattices, X-ray diffraction, Braggs Law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. (repeated)

Unit III: Statistical Thermodynamics

Thermodynamic probability and entropy, Boltzman distribution, partition function, Thermodynamic function, and equilibrium constant in terms of partition function, Einstein's theory of specific heat of solids, Debye T3 laws.

Chemical Kinetics: Kinetics of complex reactions, opposing reactions, parallel reactions, consecutive or chain reactions. Theories of reaction rates, Arhenius eqn. collision theory, theory of absolute reaction rates. Primary and Secondary Salt effects.

Unit IV: Practical

1. Determination of molar mass of polymer by viscometric methods- polyvinyl pyrollidone.
2. Kinetic measurements of acid hydrolysis of esters.
3. Partition or distribution co-efficient of I_2 between CCl_4 &H_20.
4. To study reaction rate between acetone & I_2 in presence of an acid.
5. Precipitation by conductometric titration (KCl & AgNO3 solution)
6. Iodination of acetone
7. Adsorption of oxalic acid and acetic acid on activated charcoal

CHE-UG-502: Spectroscopy

Unit I: Molecular symmetry & Group theory

Symmetry elements, symmetry operation, Group multiplication table H_2O &NH_3, Laws of group theory.

Molecular Spectroscopy: Interactions of electromagnetic radiation with molecules and various types of spectra; bonds-Born-Openheimer approximation, rotation spectroscopy- rigid rotator, SHM, intensities of spectral lines, determination of bond length of di-atomic and tri-atomic molecules, isotopic substitutions.

Unit II: Vibrational Spectroscopy

Vibrational terms, classical equation of vibrations, vibrational energy of diatomic molecules, zero point energy, computation force constant, amplitude of diatomic molecular vibrations, anti hormonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degree of freedom for poly atomic molecule, concept of group frequencies, vibrational and rotational spectroscopy, diatomic vibrating rotator, P, Q, R branches.

Electronic Spectroscopy: Frank- Condon principle, electronic transition, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transition of polyenes using free electron model,

Unit III: Spectroscopy of Organic Compounds UV, IR, MS

General concept and applications in structural determination of simple organic compounds.

Magnetic resonance, NMR spectroscopy: Principle, Larmor precession, chemical shift and low resolution spectra, different scales, spin-spin coupling, spin-lattice and spin-spin relaxations, exchange process High resolution spectra, interpretation of PMR

spectra of A-X organic molecules. Application of PMR and CMR (structure elucidation of organic compounds). Electronic spin resonance and its principle, hyperfine structure, ESR of simple radicals.

Unit IV: Practical

Practical may be substituted by a term paper on any of the techniques and applications

CHE-UG-601: Instrumental Techniques

Unit I: Treatment of Analytical Data

Accuracy/Precision, Classification of errors/Minimization of errors, Simple statistics, Frequency, statistics, distribution curve, Mean, Median, Mode, Standard Deviation, Comparison of Data Least square methods, Quantification and Confidence intervals, Sampling and correlation.

Unit II: Gravimetry

Principles, Co-precipitation and post precipitation, Removal and minimization of errors in gravimetric procedures, Efficiency of washing.

Unit III: Chromatography

Basic principles, Column chromatography, Thin layer chromatography,Rf value, Paper chromatography, Gas chromatography, Flash chromatography, HPLC.

Unit III: Solvent Extraction

Theory and basic principles, Choice of solvents, separation factor, complexing agent, Efficiency and Percentage extraction.

Ion Exchange: Theory and principles, Ion exchange resins, quality of resins, Ion exchange capacity and ion exchange equilibrium, Deionization of water.

Electro-analytical chemistry: Liquid junction potential,Standard electrode potential, Sign convention, Electrochemical series and its, significance, Redoxpotential/Formal potential/Redox indicators, Polarisation /Over voltage, Voltametry (Theory and principles)/Theory of corrosion. Potentiometric titrations.

Unit IV: Practical

1. Separation of mixture of diastereisomer by TLC.
2. Separation of amino acids by TLC.
3. Determination of hardness of water.
4. Detection and estimation of metal ions in a soil and water samples by flame photometer.
5. Potentiometric titration.
6. Use of software for obtaining ground state energy of lithium and beryllium.

CHE-UG-602: Bio and Medical Chemistry

Unit I: Biological Chemistry

Prokaryotic and Eukaryotic Cells: Differentiate between prokaryotes and eukaryote. Structure of a bacterial cell wall and its function. Structure of cell wall of a plant. Local and botanical names of any ten (10) medicinal plants of the Sikkim Himalayas, and their traditional uses in treatment of human diseases.
Structure and Function of Biomolecules: Carbohydrates, Lipids, Amino acids and proteins, Nucleic acid: DNA and RNA, Coenzymes and cofactors.

Unit II: Basic Concepts in Enzymology
Enzymes catalyzed reactions, enzymes structure (definitions of primary, secondary, tertiary and quaternary), and mechanism of enzyme actions, Lock and key rule, enzyme kinetics, Michalles-Menlea equation, industrial enzymes, and applications of enzyme in organic synthesis.
Basic Techniques in Biochemistry: Protein estimation, DNA, RNA estimation, Electrophoresis, column chromatography (principles & application only).
Bio-inorganic Chemistry: Trace elements in organisms, Metalloporphyrins with special reference to hemoglobin and myoglobin.

Unit III: Medicinal Chemistry
Definition, structure, mode of action and use of antibiotics viz. Ampicillin, penicillin, streptomycin and tetracycline. Synthesis and use of paracetamol, aspirin and the use of isoxazole and isoxazolidines.

Unit IV: Practical
1. Identification of liquid organic compounds (functional groups, preparations of derivatives and melting points/boiling points).
2. Quantitative estimation of phenol (bromide-bromate method).
3. Ninhydrin test foramino acids proteins.
4. Separation of pigments by paper chromatography.
5. Extraction of bioactive compounds from any local medicinal plant.
6. Visits to laboratories/industries (at least 2).

Reading List

Biochemistry

1. Plummer : Practical Biochemistry
2. Conn and Stumpf : Elements in Biochemistry
3. Lehninger : Biochemistry
4. Stryer : Biochemistry
5. Bertini : Biological Inorganic Chemistry
6. Reddy : Bioinorganic Chemistry
7. Gray : Bioinorganic Chemistry
8. Lippard : Principles of Bioinorganic Chemistry

Organic Chemistry

1. Finar : Organic Chemistry (Vol I and II)

2. Morrisson and Boyd : Organic Chemistry
3. March : Advanced Organic Chemistry
4. Solomon : Organic Chemistry (Vol I and II)
5. Carey : Organic Chemistry
6. Loudon : Organic Chemistry
7. Mukherjee , Singh and Kapoor :
8. Organic Chemistry (Vol I, II and III)
9. Sykes : A Guide to Mechanism of Organic
10. Eliel : Stereochemistry of Organic Compounds

Physical Chemistry

1. West : Solid State Chemistry and Its Applications,
2. Billmeye : Textbook of Polymer Science
3. Barrow : Physical Chemistry
4. Tembe : Statistical Mechanics
5. Bockris : Modern Electrochemistry
6. Chandra : Introduction to Quantum Chemistry
7. Glasstone : Electrochemistry
8. Castellan : Physical Chemistry
9. Tareen and Kutty : Basic Course in Crystallography
10. Rajaram and Kuriacose : Kinetics and Mechanism of Chemical Transformations

Inorganic Chemistry

1. Huheey, Keiter, Keiter and Medhi : Inorganic Chemistry
2. Tarr and Miesler : Inorganic Chemistry
3. Mendham : Vogel's textbook of Quantitative Chemical Analysis
4. Svelha : Vogel's Qualitative Chemical Analysis
5. Sakurai : Advanced Quantum mechanics
6. Sakurai : Basic Quantum Mechanics
7. Christian : Analytical chemistry
8. Cotton : Basic Inorganic Chemistry
9. Cotton : Advanced Inorganic Chemistry
10. Douglas: Concepts and Models of Inorganic Chemistry