Syllabus

for

**B.Sc. (Honours) Course in**

**CHEMISTRY**

**Choice Based Credit System**

Effective from the Session 2016-17

**KAZI NAZRUL UNIVERSITY**

**Asansol**

**West Bengal**

**Kazi Nazrul University**

**Curriculum for B. Sc. Honours Course in Chemistry**

**Semester - I**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of the Subject** | **Nature** | **Code** | **Teaching Scheme in hour per week** | **Credit** |
| **L** | **T** | **P** |
| 1 | Inorganic Chemistry– I (Theory) | Core Course – I  |  |  |  |  | 6 |
| 2 | Organic Chemistry – I (Theory) | Core Course – II  |  |  |  |  | 6 |
| 3 | GE – I (Mathematics Theory) | GE  |  |  |  |  | 5 |
| 4 | GE – I (Mathematics Tutorial) | GE  |  |  |  |  | 1 |
| 5 | EVS | AECC |  |  |  |  | 2 |
| **Total Credit = 20** |

**Semester - II**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of the Subject** | **Nature** | **Code** | **Teaching Scheme in hour per week** | **Credit** |
| **L** | **T** | **P** |
| 1 | Physical Chemistry– I (Theory) | Core Course – III  |  | 4 |  |  | 4 |
| 2 | Physical Chemistry– I (Lab) |  |  |  |  | 2 | 2 |
| 3 | Organic Chemistry – II (Theory) | Core Course – IV  |  | 4 |  |  | 4 |
| 4 | Organic Chemistry – II (Lab) |  |  |  |  | 2 | 2 |
| 5 | GE – II (Mathematics Theory) | GE  |  |  |  |  | 5 |
| 6 | GE – II (Mathematics Tutorial) | GE  |  |  |  |  | 1 |
| 7 | English | AECC |  |  |  |  | 2 |
| **Total Credit = 20** |

**Semester - III**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of the Subject** | **Nature** | **Code** | **Teaching Scheme in hour per week** | **Credit** |
| **L** | **T** | **P** |
| 1 | Inorganic Chemistry– II (Theory) | Core Course – V  |  | 4 |  |  | 4 |
| 2 | Inorganic Chemistry– II (Lab) | Core Course – V |  |  |  | 2 | 2 |
| 3 | Organic Chemistry – III (Theory) | Core Course – VI  |  | 4 |  |  | 4 |
| 4 | Organic Chemistry – III (Lab) | Core Course – VI |  |  |  | 2 | 2 |
| 5 | Physical Chemistry – II (Theory) | Core Course – VII |  | 4 |  |  | 4 |
| 6 | Physical Chemistry – II (Lab) | Core Course – VII |  |  |  | 2 | 2 |
| 7 | GE – III (Mathematics/Physics Theory) | GE  |  |  |  |  | 5/4 |
| 8 | GE – III (Mathematics Tutorial/  Physics Lab) | GE  |  |  |  |  | 1/2 |
| 9 | SEC – I  | AEEC – I  |  |  |  |  | 2 |
| **Total Credit = 26** |

**Semester - IV**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of the Subject** | **Nature** | **Code** | **Teaching Scheme in hour per week** | **Credit** |
| **L** | **T** | **P** |
| 1 | Inorganic Chemistry– III (Theory) | Core Course–VIII  |  | 4 |  |  | 4 |
| 2 | Inorganic Chemistry– III (Lab) | Core Course–VIII |  |  |  | 2 | 2 |
| 3 | Organic Chemistry – IV (Theory) | Core Course – IX |  | 4 |  |  | 4 |
| 4 | Organic Chemistry – IV (Lab) | Core Course – IX  |  |  |  | 2 | 2 |
| 5 | Physical Chemistry – III (Theory) | Core Course–X |  | 4 |  |  | 4 |
| 6 | Physical Chemistry – III (Lab) | Core Course – X |  |  |  | 2 | 2 |
| 7 | GE – IV (Mathematics/Physics Theory) | GE  |  |  |  |  | 5/4 |
| 8 | GE – IV (Mathematics Tutorial/  Physics Lab) | GE  |  |  |  |  | 1/2 |
| 9 | SEC – II  | AEEC – II  |  |  |  |  | 2 |
| **Total Credit = 26** |

**Semester - V**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of the Subject** | **Nature** | **Code** | **Teaching Scheme in hour per week** | **Credit** |
| **L** | **T** | **P** |
| 1 | Organic Chemistry– V (Theory) | Core Course–XI  |  | 4 |  |  | 4 |
| 2 | Organic Chemistry– V (Lab) | Core Course–XI |  |  |  | 2 | 2 |
| 3 | Inorganic Chemistry – IV (Theory) | Core Course – XII  |  | 4 |  |  | 4 |
| 4 | Inorganic Chemistry – IV (Lab) | Core Course–XII |  |  |  | 2 | 2 |
| 5 | DSE – I (Theory) | DSE – I  |  |  |  |  | 6 |
| 6 | DSE – II (Theory) | DSE – II  |  |  |  |  | 6 |
| **Total Credit = 24** |

**Semester - VI**

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| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Name of the Subject** | **Nature** | **Code** | **Teaching Scheme in hour per week** | **Credit** |
| **L** | **T** | **P** |
| 1 | Inorganic Chemistry– V (Theory) | Core Course–XIII  |  | 4 |  |  | 4 |
| 2 | Inorganic Chemistry– V (Lab) | Core Course–XIII |  |  |  | 2 | 2 |
| 3 | Physical Chemistry – IV (Theory) | Core Course – XIV  |  | 4 |  |  | 4 |
| 4 | Physical Chemistry – IV (Lab) | Core Course – XIV |  |  |  | 2 | 2 |
| 5 | DSE – III (Theory) | DSE – III  |  |  |  |  | 6 |
| 6 | DSE – IV (Theory) | DSE – IV  |  |  |  |  | 6 |
| **Total Credit = 24** |

**Total Credit = 140**

**KAZI NAZRUL UNIVERSITY**

Syllabus for B.S.c. (Honours) Course in Chemistry

Course Structure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SEMESTER – I  | **Paper** | **Core Subject** | **Marks**  | **Credit** |
| BCHEM 0101 | Inorganic –I (Theoretical) | 50 | 6 |
| BCHEM 0102 | Organic – I (Theoretical) | 50 | 6 |
| SEMESTER – II  | **Paper** | **Core Subject** | **Marks**  | **Credit** |
| BCHEM 0201 | Physical – I (Theoretical) | 50 | 4 |
| BCHEM 0202 | Physical – I (Lab) | 50 | 2 |
| BCHEM 0203 | Organic – II (Theoretical) | 50 | 4 |
| BCHEM 0204 | Organic – II (Lab) | 50 | 2 |
| SEMESTER – III  | **Paper** | **Core Subject** | **Marks**  | **Credit** |
| BCHEM 0301 | Inorganic –II (Theoretical) | 50 | 4 |
| BCHEM 0302 | Inorganic –II (Lab) | 50 | 2 |
| BCHEM 0303 | Organic – III (Theoretical) | 50 | 4 |
| BCHEM 0304 | Organic – III (Lab) | 50 | 2 |
| BCHEM 0305 | Physical – II (Theoretical) | 50 | 4 |
| BCHEM 0306 | Physical – II (Lab) | 50 | 2 |
|  | **Skill Enhancement Course [SEC] (Any one)** |  |  |
| BCHEM 0307 | Industrial Chemistry | 50 | 2 |
| BCHEM 0308 | Pharmaceutical Chemistry | 50 | 2 |
| SEMESTER – IV  | **Paper** | **Core Subject** | **Marks**  | **Credit** |
| BCHEM 0401 | Inorganic –III (Theoretical) | 50 | 4 |
| BCHEM 0402 | Inorganic –III (Lab) | 50 | 2 |
| BCHEM 0403 | Organic – IV (Theoretical)  | 50 | 4 |
| BCHEM 0404 | Organic – IV (Lab) | 50 | 2 |
| BCHEM 0405 | Physical – III (Theoretical) | 50 | 4 |
| BCHEM 0406 | Physical – III (Lab) | 50 | 2 |
|  | **Skill Enhancement Course [SEC] (Any one)** |  |  |
| BCHEM 0407 | Chemistry of Cosmetics & Perfumes | 50 | 2 |
| BCHEM 0408 | Fuel Chemistry | 50 | 2 |
| SEMESTER – V  | **Paper** | **Core Subject** | **Marks**  | **Credit** |
| BCHEM 0501 | Organic –V (Theoretical) | 50 | 4 |
| BCHEM 0502 | Organic –V (Lab) | 50 | 2 |
| BCHEM 0503 | Inorganic – IV (Theoretical)  | 50 | 4 |
| BCHEM 0504 | Inorganic – IV (Lab) | 50 | 2 |
|  | **Discipline Centric Electives [DCE] (Any Two)** |  |  |
| BCHEM 0505 | Green Chemistry | 50 | 6 |
| BCHEM 0506 | Environmental Chemistry | 50 | 6 |
| BCHEM 0507 | Solid State Chemistry  | 50 | 6 |
| SEMESTER – VI  | **Paper** | **Core Subject** | **Marks**  | **Credit** |
| BCHEM 0601 | Inorganic – V (Theoretical) | 50 | 4 |
| BCHEM 0602 | Inorganic – V (Lab) | 50 | 2 |
| BCHEM 0603 | Physical – IV (Theoretical) | 50 | 4 |
| BCHEM 0604 | Physical – IV (Lab) | 50 | 2 |
|  | **Discipline Centric Electives [DCE] (Any Two)**  |  |  |
| BCHEM 0605 | Chemistry of Nanomaterials | 50 | 6 |
| BCHEM 0606 | Dynamic Stereochemistry | 50 | 6 |
| BCHEM 0607 | Quantum Chemistry & Spectroscopy | 50 | 6 |

[N.B.: Digital analytical balance (accuracy up to third/fourth decimal) must be used for experiments on inorganic, analytical and physical chemistry.]

**SEMESTER – I (Total Marks 100, Credit 12)**

**BCHEM 0101: Inorganic Chemistry – I (Core-I) Marks 50, Credit 6**

**Unit-I: Atomic Structure and Nuclear Chemistry (16 L)**

Nuclear Stability: neutron-proton ratio and Segre’s chart, modes of decay and neutron proton-ratio, packing fraction, mass defect and nuclear binding energy, magic number; Radioactive decay, units of radioactivity, different modes of decay, half-life and average life of radioelements, radioactive equilibrium, natural radioactive disintegration series, principles of determination of age of rocks and minerals, radio carbon dating, disintegration series (Naturally occurring), group displacement law, artificial radioactivity, nuclear fission, fusion reaction and spallation, nuclear energy and power generation, application of radioactivity in analytical chemistry

Bohr’s theory and its limitation, Sommerfeld theory (no derivation) and hyperfine splitting of spectral lines, Bohr’s correspondence principle, de Broglie matter waves, penetration and quantum defects of atomic orbitals, concept of atomic orbitals: shapes, radial and angular wavefunction (qualitative idea), radial distribution probability function of s, p, d and f orbitals (qualitative idea); significance of different quantum numbers, many electron atoms and ions: Pauli’s exclusion principle, Hund’s rule, Aufbau principle; energy level of atomic orbitals and writing of the electron configuration of atoms, term symbols of atoms and ions (some illustrative examples)

**Unit-II: Periodic Table and Periodic properties (15 L)**

Modern version of the periodic table and extended periodic table, connection among valency/oxidation number, electron distribution, position of the elements

Periodicity of properties: atomic radii, ionic radii, covalent radii, Vander Waals radii, ionization energy, ionic potential, electron affinity, electronegativity, Pauling’s, Mulliken’s, Jaffe-Hinzes’ and Allred-Rochow’s scales; electronegativity equalization principle, controlling factors, applications, Effective nuclear charge (Slater’s rule, elementary calculations), catenation, metallic and non-metallic character

 Properties of boarder line elements, secondary periodicity, relativistic effects, exchange energy, inert pair effect, diagonal relationship, peculiarity of the first and second row elements

**Unit-III: Chemical Bonding in Covalent Compounds (Preliminary Concept) (15 L)**

Concept of hybridization: directional character of covalent bonds, equivalent and non-equivalent hybrid orbitals, Bent’s rule, resonance effects and resonance energy, covalent bond energy and bond length, Controlling factors; Valence Shell Electron Pair Repulsion theory (VSEPR): Shape of the molecular species, stereochemically active lone pairs, VSEPR in the light of electron domain theory

Covalent radii (tetrahedral and octahedral); partial ionic character in covalent bonds, Pi-bonding: pπ-pπ, pπ-dπ and dπ-dπ interaction, importance in controlling different molecular properties (C vs Si, N vs P, O vs S etc); π-bonding in boron compounds, π-bonding and properties of oxyacids of different nonmentals, electron deficient Covalent bonds (Qualitative approach): 2c-1e, 2c-3e, 3c-2e (H-bridge bond), banana bonds, odd electron molecules

**Unit-IV: Molecular Orbital Theory of Covalent Compounds and Some Aspects of Covalent Bonding (14 L)**

Molecular orbital theory (MOT): LCAO approach, shape and symmetry of the bonding and antibonding molecular orbitals, symmetry elements of the sigma, pi and delta molecular orbitals, bond orders, bond lengths

Molecular orbital models for homonuclear diatomic species, interaction of hybride atomic orbitals, symmetry interaction among the Mos, conditions of LCAO, bond order, molecular orbital models for heteronuclear diatomic species: CO, NO, HCl, etc and polyatomic species (e.g. H2O, BeH2 CO2, BF3 etc.), MOT of Inert gas compounds (3c-4e bond)

**BCHEM 0102: Organic Chemistry – I (Core-II) Marks 50, Credit 6**

**Unit-I:** **Classification and nomenclature** (**3 L)**

Classification of organic compounds; Nomenclature with special reference to polycyclic, bridge-head, aromatic, heterearomatic and heterocyclic compounds.

**Unit-II: Structure, bonding and properties of Organic molecules; Organic acid-bases (11 L)**

Hybridisation of atomic orbitals; orbital picture of ethane, ethene, ethyne, allene and benzyne; state of hybridisation and bonding properties; delocalised bonds, resonance, steric inhibition of resonance, hyperconjugation, tautomerism, aromaticity, non-aromaticity and anti-aromaticity; Inductive and field effect; Dipole moment; Intermolecular forces of attraction; Solute-Solvent interaction; Acid base principles; Relation between structure and acidity & basicity; Effect of solvent on acids and bases; Molecular orbitals of ethylene, butadiene and hexatriene; HOMO and LUMO concept.

**Unit-III: Organic reaction mechanism : An Introduction (14 L)**

Homolysis and heterolysis of bonds; Thermodynamics and kinetics of organic reactions, Transition state theory and Hammond's postulate with energy profile; principle of microscopic reversibility, kinetically and thermodynamically controlled reactions; Primary and Secondary kinetic isotope effects; cross over experiments; Study of Reactive intermediates : Generation, shape, stability and reactions of carbocations, carbanions, free redicals, arynes, ylides, carbenes and nitrenes; classification of organic reactions, nucleophiles and electrophiles.

**Unit-IV: Aliphatic and aromatic nucleophilic substitutions (12 L)**

Free radical and nucleophilic substitutions at sp3 Carbon; SN1,SN2, SN*i*,SN*1'*,SN*2'*reactions; NGP phase transfer catalysis; use of crown ether; functional group transformations using SN2 reactions, nucleophilic substitutions at sp2 carbon.

Aromatic SN processes : Addition – elimination mechanism, ArSN1 mechanism, elimination – addition mechanism, orientation and reactivity.

**Unit-V : Static stereochemistry-I (20 L)**

Concept of constitution, configuration and conformation of organic molecules; elements of symmetry, symmetry operations, chirality and chiral centre(s), optical activity and optical isomerism, optical rotation, optical purity, enantiomeric excess, racemisation, resolution of racemic acids, bases and alcohols, configurational nomenclature : D/L, R/S, *erythro*/*threo* ; stereochemical representation. Fischer, Newman, Sawhorse, Flying wedge and their interconversions; Axial chirality of allenes, biphenyls and their *R*/*S* descriptions. Geometrical isomerism : *cis*/*trans* and *E*/*Z* nomenclature; conformational isomerism : eclipsed, staggered, gauche arrangements; synperiplaner, synclinal, anticlinal, antiperiplaner conformations, conformational analysis of ethane *n*-butane, 1, 2 dihaloethane and ethylene glycol.

**SEMESTER – II (Total Marks 100, Credit 12)**

**BCHEM 0201: Physical Chemistry – I (Core-III) Marks 50, Credit 4**

**Unit – I: Properties of Gas (16 L)**

Idea of distribution functions, properties of gamma functions, Maxwell’s speed and energy distributions in one-, two- and three- dimensions, distribution curves, different types of speeds and their significance, principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

Collision of gas molecules, collision diameter, collision number and mean free path, frequency of binary collision in same and different molecules, wall collision and rate of effusion

Andrew’s and Amagat’s plots, compressibility factor, van der Waals equation and its features, critical constants and critical state, law of corresponding states, virial equation; significance of second virial coefficient, Boyle temperature, Dieterici equation and its features

**Unit – II: Thermodynamics I (12 L)**

Basic formalism, concept of thermal equilibrium and zeroth law of thermodynamics, state and path functions, partial derivatives and cyclic rule, concept of heat and work, reversible and irreversible processes, graphical representation of work done

First law, U and H as state functions, concept of CP and CV and their relations, Joule’s experiment and its consequence, isothermal and adiabatic processes

Thermochemistry: Kirchoff’s equation, heat changes during physicochemical processes at constant P/V, bond dissociation energies, Born-Haber’s cycle

**Unit – V: Properties of Fluids (10 L)**

General features of fluid flow (streamline and turbulent flows) Reynolds number, nature of viscous drag for streamline motion, Newton’s equation, viscosity coefficient, kinetic theory of gas viscosity, viscosity of gases vs liquids, Poiseuille’s equation and its derivation, temperature dependence of viscosity, intrinsic viscosity, principle of determination of viscosity coefficients of liquids by Ostwald viscometer and falling sphere methods

Nature of the liquid state, vapour pressure, surface tension, surface energy, excess pressure, capillary rise and measurement of surface tension, condition of wetting, vapour pressure over a curved surface, temperature-dependence of surface tension, principle of determination of surface tension, concept of liquid crystals and superfluids

**BCHEM 0202: Physical Chemistry-I Lab Marks 50, Credit 2**

1. Surface tension of a liquid/solution by drop-number method.

2. Viscosity coefficient of a liquid/solution by Ostwald viscometer.

**BCHEM 0203: Organic Chemistry-II (Core-IV) Marks 50, Credit 6**

**Unit-I: Static Stereochemistry-II (8 L)**

Prochirality, topicity of ligands and faces (*Pro* – *R*, *Pro* – *S* and *Re*/*Si*; designation). Asymmetric synthesis; Cram's rule. Conformational analysis of cyclohexane and its mono and di-subsituted derivatives with chair, boat and twist boat forms and their symmetry properties, and their chiroptic properties.

**Unit-II : Elimination Reactions (6 L)**

E1, E2 and E1CB mechanisms, their mechanistic spectrum, orientation, stereoselectivity; elimination vs substitution; *syn*-elimination : Pyrolysis of ester, Xanthate, *tert* – N oxide.

**Unit-III : Electrophilic and radical addition to C – C multiple bonds (8 L)**

Halogenation, hydrohalogenation, hydration, hydrogenation, epoxidation, hydroxylation, ozonolysis, hydroboration, 1, 3 dipolar addition, electrophilic addition to conjugated dienes and allenes, radical addition of HBr; reduction of alkynes and benzenoid aromatics, Diels – Alder reaction.

**Unit-IV : Nucleophilic addition to carbonyl group (10 L)**

Reaction with water, alcohols, amines, thiols, HCN, bisulfite; Wittig reaction, MPV reduction, reduction with lithium aluminium hydride and sodium borohydride, Wolf-Kishner reduction, Clemensen reduction, Bouveault-Blanc reduction, addition of organometallics, addition of diazomethane; Cannizaro reaction, aldol condensation including directed aldol reaction, Claisen condensation, Knoevenagel reaction, Stobbe reaction, Reformatsky reaction, Mannich reaction, Darzen's glycidic ester synthesis, Perkin reaction, Benzoin condensation, nucleophilic addition (Michael addition) to α, β unsaturated carbonyl system.

**BCHEM 0204: Organic Chemistry-II Lab Marks 50, Credit 2**

Qualitative analysis of organic compound :

A. Study on Physical Properties : Physical State, Colour, odour, acid-base character, ignition, solubility and melting point.

B. Detection of special elements (N, S, Cl) by Lassaigne's test.

C. Detection of functional group : – COOH, – OH (Phenolic), – COOR, Carbonyl group (aldelydic and ketonic) , >C=C< (unsaturation), – NH2, – NO2, – CONH2 and CONHAr (anilido)

D. Preparation of a suitable derivative of one functional group present in the sample.

**SEMESTER – III (Total Marks 150, Credit 18)**

**BCHEM 0301: Inorganic Chemistry – II (Core-V) Marks 50, Credit 4**

**Unit-I: Chemistry of s and p Block Elements (14 L)**

General properties of s- and p-block elements, Comparative account of physical and chemical properties of the s and p-block elements, the diagonal relationship, variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation properties (if any), hydrides, halides, oxides, oxy-acids (if any), inert pair effect (if any), complex chemistry (if any) in respect of the following elements

(i) S-block elements: Li-Na-K, Be-Mg-Ca-Sr-Ba.

(ii) P-block elements: B-Al-Ga-In-Tl, C-Si-Ge-Sn-Pb, N-P-As-Sb-Bi, O-S-Se-Te,

F-Cl-Br-I, He-Ne-Ar-Kr-Xe

Properties and reactions of important compounds

(i) Structure, bonding and reactivity of B2H6; (SN)x with x = 2, 4; phosphazines;

interhalogens. (ii) Structure of borates, silicates, polyphosphates, borazole, boron nitride,

silicones, thionic acids. (iii) Reactivity of polyhalides, pseudo halides, fluorocarbons,

freons and NOx with environmental effects. (iv) Chemistry of hydrazine, hydroxylamine,

N3-, thio- and per-sulphates

Compounds of Noble Gases: structure, preparation and reactivity

**Unit-II: Acids and Bases and Ionic Equilibria (15 L)**

Brönsted Lowry’s concept, cosolvating agents, differentiating and leveling effect, Theory of solvent system, Lux-Flood concept, Lewis concept- Stability of the adduct (Drago-Wayland equation), change of bond length parameter in adduct formation, π-acidity of the ligands, synergistic effect, Usanovich’s concept

Strength of hydracids and oxyacids, different factors in determining acid-base strength: inductive effect and hyperconjugation, steric effects (B- and F-strain), salvation, H-bonding

Hard and Soft acid base (HSAB) principle: classification and characteristic, hardness and frontier molecular orbital (FMO), electronegativity and hardness and softness, symbiosis, theoretical back ground, application of the concept; acid-base equilibria in solution: hydrolysis of salts, PH calculation, buffer, acid-base neutralization curves and selection of indicator

**BCHEM 0302: Inorganic Chemistry – II Lab Marks 50, Credit 2**

Qualitative analysis

Qualitative analysis of mixtures containing not more than four radicals from among the following:

BASIC RADICALS: Silver, lead, mercury, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminium, manganese, chromium, nickel, cobalt, zinc, calcium, strontium, barium, sodium, potassium

ACID RADICALS: Chloride, bromide, iodide, bromate, iodate, silicate, fluoride, arsenite, arsenate, phosphate, nitrite, nitrate, sulphide, sulphite, thiosulphate, suplhate, borate, ferro/ferri-cyanide, chromate, dichromate

Insoluble Materials: Al2O3, Fe2O3, Cr2O3, SnO2, SrSO4, BaSO4, CaF2.

**BCHEM 0303: Organic Chemistry – III (Core-VI) Marks 50, Credit 4**

**Unit-I: Molecular rearrangements and Named reactions (10 L)**

Wagner-Meerwein, Pinacol-Pinacolones, Dakin, Bayer-Villiger, Beckmann, Favorsky, Hoffmann, Lossen, Schmidt, Curtius, Benzil – benzilic acid, dienone-phenol, Wolf, Claisen, Fries, Photo Fries, Orton, Demjanov, Benzidine Semidine.

Birch, Von Richter, Houben-Hoesch, Arndt-Eistert homologation, HVZ, Hunsdiecker, Oppenaur, Sandmeyer, Stephen, Williamson ether synthesis.

**Unit-II: Aromatic electrophilic substitutions (8 L)**

Mechanism, orientation and reactivity; nitration, nitrosation sulfonation, halogenation Friedel-Crafts, Haworth Synthesis, Gatterman – Koch, Gatterman, Hoesch, Vilsmeier – Haack, Reimer – Tiemann, Kolbe – Schmidt, Chloromethylation, Manasse, Kolbe.

**Unit-III: Synthesis, physical properties and reactions (10 L)**

(i) Aliaphatic and aromatic nitrogen compounds : amines, nitro compounds, nitro alkanes, alkyl nitrites, aromatic diazonium compounds, dilzomethane; (ii) nitrophenols, amionophenols, nitro anilines, amino carboxylic acids.

**BCHEM 0304: Organic Chemistry – III Lab Marks 50, Credit 2**

Quantitative analysis of organic compound :

Estimation of : 1. Glucose by Fehling’s solution, 2. Acetone, 3. Aniline

**BCHEM 0305: Physical Chemistry – II (Core-VII) Marks 50, Credit 4**

**Unit – I: Thermodynamics II & Application (20 L)**

Second law of thermodynamics and its need, Kelvin, Planck and Clausius statements and their equivalence, Carnot cycle and refrigerator, Carnot’s theorem, thermodynamic scale of temperature

Physical concept of entropy, Clausius inequality, entropy change of system and surroundings for various processes and transformations, entropy change during isothermal mixing of ideal gases, entropy and unavailable work, auxiliary state functions (G and A) and their variations with T, P and V, criteria of spontaneity and equilibrium

Thermodynamic relations, Maxwell relations, thermodynamic equation of state, Gibbs-Helmholtz equation and its consequence, Joule-Thomson (J-T) experiment inversion temperature, J-T coefficient for a van der Waals gas, general heat capacity relations

Additivity rule, partial molar quantities, chemical potential and its variation with T and P, Gibbs-Duhem equation, fugacity of gases and fugacity coefficient

**Unit – II: Statistical Thermodynamics & Third Law (8 L)**

Thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation), application to barometric distribution, partition function and thermodynamic properties (U, H & P), Einstein’s theory of heat capacity of solids and its limitations

Nernst heat theorem and its implications, approach to zero Kelvin, Planck’s formulation of third law and absolute entropies

**Unit – III: Chemical Kinetics –I (10 L)**

Introduction, reaction rate and extent of reaction, order and molecularity; kinetics of zero, first, second, fractional and pseudo-first order reactions; determination of order of reaction, opposing, consecutive and parallel reactions (first order), concept of steady state and rate determining step, chain reaction: elementary idea, illustrations with H2-Br2 and H2-O2 reactions

Temperature dependence of reaction rate, Arrhenius equation

**Unit – IV: Ionic Equilibria (6 L)**

Ostwald’s dilution law, pH, buffer solution and buffer capacity, Henderson equation, hydrolysis and hydrolysis constant of salts, indicators: acid-base and its function, Hammett acidity function

**Unit - V. Properties of Solid (6 L)**

Unit cell, Bravais lattice, crystal system, packing in cubic crystals, Miller indices, Bragg’s equation and its applications, crystal structures of NaCl and KCl, Crystal defects

**BCHEM 0306: Physical Chemistry – II Lab Marks 50, Credit 2**

1. Kinetics of decomposition of H2O2 by potassium iodide.

2. Solubility/solubility product of Mg-carbonate in presence/absence of common ions and/or neutral electrolytes.

**BCHEM 0307: Industrial Chemistry (SEC) Marks 50, Credit 2**

**Water (3 L)**

Types of water, analysis of water (different types of hardness), for municipal and industrial use

**Electrochemical and Electro-thermal Industries (3 L)**

Preparation and use of Potassium permanganate, hydrogen peroxide, synthetic graphite, calcium carbide, carborundum, alloy steels

**Ceramics (4 L)**

Refractories, pottery, porcelain, glass, fibre glass

**Rusting of Iron and Steel (3 L)**

Cause and prevention of corrosion

**Industrial Safety and Fire Protection (4 L)**

Flash point, fire extinguishers – foam, carbon dioxide, sprinkler system, inert gases.

**Pollution (3 L)**

Types of wastes – industrial, domestic, electronic; their causes and control

**BCHEM 0308: Pharmaceutical Chemistry (SEC) Marks 50, Credit 2**

**Drugs & Pharmaceuticals (15 L)**

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, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

**Fermentation (5 L)**

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

**SEMESTER – IV (Total Marks 150, Credit 18)**

**BCHEM 0401: Inorganic Chemistry – III (Core-VIII) Marks 50, Credit 4**

**Unit-I: Chemistry of d and f Block Elements (15 L)**

d-Block elements: general comparison of 3d, 4d and 5d elements with special reference to electronic configuration, variable valency, ability to form coordination complexes, spectral magnetic catalytic properties

f-Block Elements: comparison of the general properties (e.g. electronic configuration, oxidation state, variation in atomic and ionic (3+) radii, complex formation, magnetic and spectral properties) of lanthanides and actinides, f-contraction, similarities between the later actinides and the later lanthanides, spectral properties (in comparison with the d-block elements), isolation and occurrence, use of the metals, principle of separation of lanthanides, chemistry of separation of Np, Pu and Am from U

Chemistry of some representative compounds: K2Cr2O7, KMnO4, K4[Fe(CN)6], K2[Ni(CN)4], H2PtCl6, Na2[Fe(CN)5NO]

**Unit-II: Coordination Chemistry-I: Bonding in Coordination Compounds (Preliminary Concept) and Properties of Coordination Compounds (16 L)**

Werner’s Coordination theory, different types of ligands, metal chalates, IUPAC nomenclature of coordination compounds, electronic theory of complex compounds, effective atomic number (EAN) and its limitations, Valence bond theory in coordination compounds: different geometry, outer and inner orbital complexes, magnetic criterion of bond type, Principle of electroneutrality of atoms, limitations of VBT

Stereochemistry, Coordination number, factors favouring low and high coordination numbers, isomerism (ionization, hydrate, ligand, linkage, coordination, geometrical and optical etc.) in coordination compounds, concept of Stability constant (stepwise and overall), chelate effect, macrocyclic effect and macropolycyclic effect, labile and inert complexes, substitution reaction on square planer complexes, trans-effect (preliminary concept) in square planar complexes, application of coordination complexes in chemical analysis, elucidation of structure of coordination compounds, metal complexes in biosphere

**BCHEM 0402: Inorganic Chemistry – III Lab Marks 50, Credit 2**

Preparation

Chrome alum, Mohr’s salt, Cuprommonium sulphate, sodium nitroprusside, hexamine cobalt(III) chloride, tris (ethane 1,2-ammine) nickel(III) chloride

**BCHEM 0403: Organic Chemistry – IV (Core-IX) Marks 50, Credit 4**

**Unit-I: Heterocyclic compounds (6 L)**

Syntheses, properties and uses of furan, pyrrole, thiophene, pyridine, quinoline, isoquinoline and indole

**Unit-II: Alicylic compounds (3 L)**

Structure of simple alicyclic compounds up to six-membered ring; strain theory in classical and modern theoretical approach, effect of strain on reaction, ring synthesis-principles controlling ring closure reactions, rules for ring closure (Baldwin's rule), ring expansion and contraction process.

**Unit-III: Amino acids and Proteins (6 L)**

Essential and non-essential amino acids, isoelectric point, ninhydrin reaction, synthesis of glycine, alanine and tryptophan; classification of proteins, geometry of peptide linkage, elementary idea about primary and secondary structures of proteins; C-terminal, N-terminal and their determination; peptide synthesis, Merrifield synthesis

**Unit-IV: Carbohydrate chemistry (8 L)**

Chemistry of monosaccharides and disaccharides including structures and configurations: D-glucose, fructose, and sucrose; stepping-up and stepping-down of monosaccharides, conversion of aldose to ketose and vice versa; mutarotation, epimerization, anomeric effect, reducing sugars, elementary idea about starch and cellulose

**Unit-V: Alkaloids and Terpenenoids (6L)**

Introductory discussion on terpenenoids and alkaloids; biosynthesis of squalene; determination of structures of *citral*, α-*terpineol*, piperine, ephedrine and coniine

**BCHEM 0404: Organic Chemistry – IV Lab Marks 50, Credit 2**

Identification with general reaction and tests of the following compounds:

a) Methyl alcohol, b) Ethyl alcohol, c) Acetone, d) Formic acid, e) Acetic acid, f) aniline, g) Nitro benzene, h) Tartaric acid, i) Succinic acid, j) Salicylic acid, k) Glucose l) Resorcinol

**BCHEM 0405: Physical Chemistry – III (Core-X) Marks 50, Credit 4**

**Unit – I: Chemical Equilibrium (6 L)**

Thermodynamic condition of equilibrium, degree of advancement and Le Chatelier’s principle, Van’t Hoff isotherm, isobar and isochore

**Unit – II: Electrochemistry (20 L)**

Conductance and its measurement, cell constant, specific and equivalent conductances, their variations with dilution for strong and weak electrolytes, molar conductance, transport number and determination by Hittorf methods, Kohlrausch’s law, Walden’s rule, ion conductance and ionic mobility, application of conductance measurement (determination of solubility product and ionic product of water), conductometric titrations

Ion atmosphere, asymmetry and electrophoretic effects, Wien effect and Debye-Falkenhagen effect, Activity and activity coefficients of electrolyte/ion in solution, Debye-Hückel theory, Debye-Hückel limiting law (with derivation), solubility equilibrium and influence of common and indifferent ions

Electrochemical cells, half cells/electrodes with types and examples, cell reactions and thermodynamics of cell reactions, Nernst equation, standard cells, calomel, Ag/AgCl, quinhydrone and glass electrodes: features and applications, potentiometric titrations (acid base and redox), concentration cells, liquid junction potential

**Unit – III: Chemical kinetics –II (6 L)**

Collision theory of bimolecular reactions, unimolecular reactions, Lindemann theory, transition state theory, free energy and entropy of activation, pressure-dependence of rate constant, primary kinetic salt effect

Homogeneous catalysis, with reference to acid base and enzyme catalyses, heterogeneous catalysis

**Unit – IV: Interface & Dielectrics (12 L)**

Special feature of interfaces, physical and chemical adsorptions, Langmuir and Freundlich adsorption isotherms, surface excess and Gibbs adsorption isotherms, heterogeneous catalysis (single reactant)

Electrical double layers, zeta potential, overvoltage, Stern double layer (qualitative idea), Tyndall effect, electrokinetic phenomena (qualitative idea), colloids and electrolytes, micelle and reverse micelle, critical micelle constant (CMC)

Electrical properties of molecules, polarizability, induced and orientation polarization, Debye and Clausius-Mossotti equations (without derivation) and their applications

Origin and types of intermolecular forces, different types of potential and their diagrams

**BCHEM 0406: Physical Chemistry – III Lab Marks 50, Credit 2**

1. Equilibrium constant of the reaction KI + I2 = KI3 by partition method.

2. Conductometric titrations of an acid or a base (acid may be monobasic/dibasic, and similarly for the base)

3. Potentiometric titrations of an acid or a base (acid may be monobasic/dibasic, and similarly for the base)

**BCHEM 0407 : Chemistry of Cosmetics & Perfumes (SEC) Marks 50, Credit 2**

**Preparation and Use of Cosmetics & Perfumes (20 L)**

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. 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.

**BCHEM 0408 : Fuel Chemistry (SEC) Marks 50, Credit 2**

**Energy Sources (6 L)**

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

*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.

**Petroleum and Petrochemical Industry (10 L)**

Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), 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. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

**Lubricants (4 L)**

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.

**SEMESTER – V (Total Marks 200, Credit 24)**

**BCHEM 0501: Organic Chemistry – V (Core-XI) Marks 50, Credit 4**

**Unit-I: Methodology in organic synthesis (8 L)**

Disconnection approach, synthons, synthetic equivalents, umpolung, one-group disconnection of alcohols, olefins and ketones; synthesis involving enolates and enamines with special reference to diethyl malonate and ethyl acetoacetate; Robinson annelation; synthesis through protection of functional groups

**Unit-II: Pericyclic reactions (8 L)**

FMO approach, definition, classification, electrocyclic reactions (including Woodward-Hofmann selection rules): [4+2] cycloaddition with special reference to Diels-Alder reaction, alder ene reaction, [2+2] cycloaddition; sigmatropic reactions: [1,j] and [i,j] shifts, [1,3] and[1,5] H-shifts, [3,3] sigmatropic shifts with reference to Cope and Claisen rearrangements

**Unit- III: Spectroscopy (15 L)**

**UV:** Electronic transitions with reference to σ-σ\*, n-σ\*, π-π\*, n-π\* transitions; absorption maximum and absorption intensity, effect of solvent; Woodward-Fischer rule with reference to conjugated system like dienes, trienes and α,β-unsaturated carbonyls including cyclic systems

**IR:** Hooke’s law, stretching and bending vibrations, characteristic and diagnostic stretching frequencies, factors affecting stretching frequencies (H-bonding, electronic factor, ring size), finger-print region, diagnostic bending frequencies for benzene and its *o*-, *m*- and *p*-isomers

**1H NMR:** Principle, nuclear spin, NMR-active nuclei, chemically equivalent and nonequivalent protons; chemical shift, upfield and downfield shifts; shielding/deshielding of protons in systems involving C-C, C=O, C=C, benzene, cyclohexane; spin-spin splitting with reference to CH3CH2Br, CH3CH2OH, Br2CHCH2Br; characteristic 1H NMR signals for simple molecules.

Application of the above spectroscopic methods in structure elucidation of simple organic molecules

**BCHEM 0502: Organic Chemistry – V Lab Marks 50, Credit 2**

Preparation -

1. Condensation :*preparation of phthalimide*

2. Nitration :*nitration of nitro benzene and acetanilide*

3. Oxidation : *Oxidisation of benzyl alcohol*

4. Hydrolysis : *hydrolysis of amide*

5. Rearrangement

 reaction : *Benzil-benzilic acid rearrangement*

**BCHEM 0503: Inorganic Chemistry – IV (Core-XII) Marks 50, Credit 4**

**Unit-I: Redox Potential and Redox Equilibria (12 L)**

Some basic aspects of redox reactions, equivalent weights of oxidants and reductants, ion-electron method of balancing redox ractions, complimentary and noncomplimentary redox reactions, disproportionation and comproportionation reactions, overpotential, electron and atom transfer in redox reactions

Standard redox potentials, sign convention, Nernst equation, electrochemical series, formal potential and its importance in analytical chemistry; Redox potential: effect of complex formation, effect of precipitation, effect of PH change, chemistry of aqua regia and mixed acids

EMF Diagram (Latimer, Frost and Pourbaix), thermodynamic aspects of disproportionation and comproportionation reactions, redox potential and equilibrium constants, clock reaction, redox titration and redox indicators, function of Zimmermann Reinhardt (ZR) solution

**Unit-II: Bioinorganic Chemistry (12 L)**

Essential metals: role of metal ions in biological systems (specially Na+, K+, Mg2+, Ca2+, Fe3+/2+, Cu2+/+, and Zn2+) and in different metalloproteins and metalloenzymes, metal ion transport across biological membrane, Na+- ion pump, ionophores, biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and carbonicanhydrase, biological nitrogen fixation, photosynthesis: photosystem-I and photosystem-II, metal dependent disease, detoxification by chelation therapy for Pb and As poisoning

Important metal complexes in medicines (Examples only), antimicrobial activity, antiarthritic gold complexes, anticancer compounds (Pt-complexes and metallocenes), lithium therapy in psychiatric mind disorder

**Unit-III: Organometallic Compounds (13 L)**

Definition, a brief history, nomenclature, classification, importance of organometallic compounds as reagents, additives and catalysts, effective atomic number rule (18 electron rule), counting of electrons

preparation, properties and bonding in - carbonyl, nitrosyl and cyanide complexes; IR-results as diagnostic tools in the identification of nature of bonding in such π-acid complexes, metal-olefin complexes: Zeise’s salt (preparation, structure and bonding), ferrocene (preparation, structure and reactions), heptacity of organometallic ligands and their examples, different types of reaction (elementary idea): oxidative addition, reductive elimination, insertion

**BCHEM 0504: Inorganic Chemistry – IV Lab Marks 50, Credit 2**

Volumetric analysis:

Redox titrations- permanganometry, dichromatometry, iodometry and iodimetry

Volumetric analysis of mixtures involving not more than two different estimations:

Fe +Cu, Fe + Cr, Fe + Ca, Ca + Ba, Ca + Mg etc.

**BCHEM 0505: Green Chemistry (DCE) Marks 50, Credit 6**

**Unit - I: Introduction to Green Chemistry (8 L)**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

**Unit – II: Principles of Green Chemistry and Designing a Chemical synthesis (34 L)**

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

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, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.

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.

**Unit – III: Examples of Green Synthesis/ Reactions and some real world cases (18 L)**

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)

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)

**BCHEM 0506: Environmental Chemistry (DCE) Marks 50, Credit 6**

**Unit-I: The Atmosphere (15 L)**

Composition and structure of the atmosphere: troposphere, stratosphere, mesosphere and thermosphere, ozone layer and its role; major air pollutants : CO, SO2, NO and particulate matters –their origins and harmful effects, problems of ozone layer depletion, green house effect, acid rain and photochemical smog, air pollution episodes, air quality standard, air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter, detection, collection and principles of estimation of CO, NOx, SO2, H2S and SPM in air samples

**Unit-II: Aspects of Environmental Inorganic Chemistry (15 L)**

Atmospheric stability and temperature inversion, greenhouse effect, global warming and cooling, ozone depletion and involved chemical reactions, the disaster of endosulfan in kasargod in kerala, smog formation, acid rain, eutrophication in natural water bodies, Minamata disease, Bhopal disaster, hazard of nuclear disaster (Chernobyl and Fukushima Daiichi), nuclear disaster management

**Unit-III: The Hydrosphere (15 L)**

Water pollutants: action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution radioactive pollution and their effects on animal and plant life, water pollution episodes, waste water treatment: chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters, desalination of sea water: reverse osmosis, electro dialysis, detection and estimation of As, Hg, Cd, Pb, Cr, NH4+ and F−,NO3−, NO2− in water sample

**Unit-IV: The Lithosphere and Pollution control (15 L)**

Soil pollution and control measures, biochemical effects of As, Pb, Cd, Hg, Cr, and their chemical speciation, monitoring and remedial measures; noise pollution, agricultural and industrial pollution, green solution to various environmental hazards

**BCHEM 0507: Solid State Chemistry (DCE) Marks 50, Credit 6**

**Unit-I: Basic Concepts and selected structure (14 L)**

Some basic crystal geometries: simples cube (sc), body centred cube (bcc), face centred cube (fcc), diamond cube (dc), close packing models: hexagonal close packing (hcp) (ABAB… type), cubic close packing (ccp) (ABCABC… type), tetrahedral and octahedral holes, packing efficiency

Structural inferences (Simple) from crystallochemical parameters; Structure of Ionic Crystals: AB-type (i.e NaCl, CsCl and {ZnS, (sphelarite and wurtzite)}, AB2 type (CaF2, SiO2 and TiO2), Ilmenite and perovskite (ABO3), spinel (AB2O4)

**Unit-II: Crystallographic Basics (14 L)**

Crystal, Steno’s Law, Hauy’s Law (law of rational intercepts), law of constancy of symmetry, Weiss indices, Miller’s indices, Unit cell, Bravis Lattice, Crystal systems, crystal class, Bragg’s equation with derivation, methods of crystal analysis, application of Bragg’s equation, crystal structure of sodium chloride and potassium chloride, Lattice vector and reciprocal lattice vector, Brillouin zone

**Unit-III: Chemical Bonding in Solids (14 L)**

Energetics of ionic bond formation and concept of lattice energy (thermodynamic basis), Born-Lande equation, Kapustinski equation, controlling factors of lattice energy.

 Ionic radii (Pauling’s crystal and univalent radii, Shannon’s crystal radii), Pauling's rules for ionic crystals, general properties of metals: free electron theory of metallic bonding (qualitative treatment), band theory and electrical properties of solids (qualitative idea), intrinsic and extrinsic semiconductor with examples from main group elements, alloys and intermetallic compounds: Hume-Rothery rules, electron compounds

**Unit-IV: Properties of Solids (18 L)**

Crystal defects: thermodynamics aspect of defects, stoichiometric and nonstoichiometric, point defects, Schottky and Frenkel, colour centres, dislocations, conductor, semiconductor, insulator in the light of band theory, n–type, p–type, semiconductors, transistor, semiconductor Hall effect and Hall co-efficient; superconductivity in solids, ferroelectricity.

**SEMESTER – VI (Total Marks 200, Credit 24)**

**BCHEM 0601: Inorganic Chemistry – V (Core-XIII) Marks 50, Credit 4**

**Unit-I: Coordination Chemistry-II: Crystal Field Theory; Magnetochemistry: Origin of Colours in Transition Metal Compounds (13 L)**

Crystal field theory: Splitting of d-orbitals in different geometries (octahedral, tetrahedral and square planar), crystal field stabilization energy (CFSE), Jahn-Teller distortion, spectrochemical series, low-spin and high-spin complexes, pairing energy, factors affecting 10Dq value, critical 10 Dq value.

Origin of colour in coordination complexes: L-S coupling, ground state terms, selection rules, Orgel diagrams, charge transfer spectra (preliminary idea)

Magnetochemistry: differnet types (dia-, para-, ferro and antiferromagnetic), orbital and spin magnetic moment, spin only moments of dn ions, superexchange and antiferromagnetic ineractions (simple examples); stabilization of unusual oxidation states of metal centres, linkage isomerism: HSAB concept and π-bonding effect.

**Unit-II: Introduction to Analytical Chemistry (10 L)**

Errors in chemical analysis: accuracy, precision, determinate, indeterminate, systematic and random errors; source, effect and detection of systematic errors; distribution of random errors; standard deviation of calculated results- sum or difference, product or quotient, significant figures, rounding and expressing results of chemical computations.

Solvent extraction, distribution ratio, principle of solvent extraction, extraction equilibrium and effect of PH; Complexometric titration, masking and demasking agents, metal indicators, Inner-metallic complexes, application in analytical chemistry.

**BCHEM 0602: Inorganic Chemistry – IV Lab Marks 50, Credit 2**

1. Complexometric Titration:

CaCO3 and MgCO3 in mixture; Mg2+ and Zn2+ in mixture.

2. Gravimetric Analysis:

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.

(ii) Estimation of copper as CuSCN.

(iii) Estimation of iron as Fe2O3 after precipitating iron as Fe(OH)3 and Heating at elevated temperature etc

3. Ion-exchanger: Cation content of a sample by cation exchanger

4. Solvent extraction

**BCHEM 0603: Physical Chemistry – IV (Core-XIV) Marks 50, Credit 4**

**Unit – I: Phase Equilibria & Colligative Properties (18 L)**

Definition of phase, component and degree of freedom, phase rule and its derivation, phase diagram, phase equilibria for one-component system: water and carbon dioxide, first order phase transition and Clapeyron equation, Clausius-Clapeyron equation: derivation and applications

Liquid-vapour equilibrium for two-component systems, Duhem-Margules equation, Henry’s law, Konowaloff’s rule, deviation from ideal behavior, azeotropic solution, liquid-liquid phase diagrams for phenol-water, triethylamine-water and nicotine-water systems, solid-liquid phase diagram, eutectic mixture, Nernst distribution law, solvent extraction

∆G, ∆S, ∆H and ∆V of mixing for binary solutions, vapour pressure of solution, ideal solutions, colligative properties, Raoult’s law; ebullioscopy, cryoscopy and osmosis (thermodynamic treatment only): inter relationships and abnormal behavior in solution, van’t Hoff *i*-factor

**Unit – II: Symmetry & Group Theory (5 L)**

Introduction, symmetry elements and operations with illustrations, symmetry elements and physical properties, group and symmetry group, group multiplication table, point group

**Unit – III: Quantum Chemistry (15 L)**

Black body radiation, Planck’s radiation law, photoelectric effect, Wilson-Sommerfeld quantization rule, application to Bohr atom, harmonic oscillator, rigid rotator and particle in 1-d box, de Broglie relation and energy quantization in Bohr atom and box, Heisenberg uncertainty principle, Bohr’s correspondence principle and its applications to Bohr atom and particle in 1-d box

Elementary concept of operators, eigenfunctions and eigenvalues, linear operators, commutation of operators, expectation value, hermitian operator, properties, Schrödinger’s time independent equation, acceptability of wave function, probability interpretation of wave function

Particle in a box, setting up of Schrödinger’s equation of 1-d box, its solution and application, degeneracy

**Unit – IV: Photochemistry & Spectroscopy (10 L)**

Primary photophysical processes, potential energy diagram, Franck-Condon principle and vibrational structure of electronic spectra, bond dissociation, decay of excited state by radiative and nonradiative paths, fluorescence and phosphorescence, Jablonsky diagram, laws of photochemistry, quantum yield, photochemical equilibrium, photosensitized reactions, kinetics of HI decomposition

Alkali metal spectra, multiplicity of spectral lines, idea of spin quantum number, physical idea of spin orbit coupling

Rotational spectroscopy of diatomic molecules, rigid rotator model, characteristic features (spacing and intensity)

Vibrational spectroscopy of diatomic molecules, Simple Harmonic Oscillator (SHO) model

**BCHEM 0604: Physical Chemistry – IV Lab Marks 50, Credit 2**

1. Kinetics of saponification of ester by conductometric method.

2. Conductometric verification of Ostwald dilution law

3. Colorimetric determination of pKin of methyl red

**BCHEM 0605: Chemistry of Nanomaterials (DCE) Marks 50, Credit 6**

**Unit-I: Basic Concepts on Nanomaterials (14 L)**

The scope and challenges of nanomaterials chemistry, the nanoscale and colloidal systems, fundamentals of surface and interfacial chemistry, chemical potential and surface curvature, surface energy and stabilization of nanoscale materials, electrostatic stabilization, interaction between two particles (DLVO theory), steric stabilization

**Unit-II: Synthesis and Fabrication of Nanomaterials (14 L)**

Top down and bottom up techniques, zero-dimensional nanomaterials: nanoparticles, synthesis of metallic, semiconducting and oxide nanoparticles, one-dimensional nanostructures: nanowire and nanorods, fundamentals of VLS and SLS growth, two-dimensional nanostructures: thin films, physical and chemical vapor deposition (PVD and CVD), Diamond films, sol-gel films

**Unit-III: Special Nanomaterials (16 L)**

Graphene, Carbon fullerenes (detailed on bonding and structure), carbon nanotubes: classification and physical characteristics, porous materials: micro and mesoporous materials, core-shell structures, quantum dot, metal-polymer structures, organic-inorganic hybrids, Metal-Organic framework (MOF), intercalation compounds, nanocomposites

**Unit-IV: Characterization, Properties and Applications of Nanomaterials (16 L)**

X-ray Diffraction (XRD), Scherrer's Formula, scanning and tunneling electron Microscopy (preliminary idea), size dependent properties: Electrical, optical, catalytic and magnetic; melting point and lattice constants, nanobots, nanocatalysis, catalysis by gold nanoparticles, biological applications of nanoparticles

**BCHEM 0606: Dynamic Stereochemistry (DCE) Marks 50, Credit 6**

**Unit-I: General Introduction (8 L)**

Regioselective, regio specific and chemoselective reactions; stereo-selectivity and stereospecificity; Stereoseleactive reactions : Classification, terminology and principles;

**Unit-II: Synthetic Approach (12 L)**

Asymmetric synthesis and Asymmetric Induction; Diastereo selective synthesis : Asymmetric synthesis with chiral substrates, cram's rule – its application and deviation, Felkin-Anh Model Prelog's rule, Enantio Selective synthesis.

**Unit-III: Stereochemical Aspects of a few Organic Reactions (20 L)**

Polar addition reactions to alkene, Prevost and woodward Hydroxylation, Hydroxylation by OsO4 followed by reductive cleavage, Catalytic reductions of alkenes and alkynes, Nucleophilic substitution on saturated carbon, E1 and E2 reaction, stereoconvergent Elimination, stereochemical aspects of a few Molecular rearrangement – Pinacol rearrangement, Beckmann rearrangement, Claisen rearrangement and Cope rearrangement.

**Unit-IV: Alicyclic system (20 L)**

Conformation and Reactivity in cyclohexanes; Steric effect and steroelectronic effect; Neighbouring group effects, effects of conformation on rearrangement and transannular reactions in alicyclic system; Diastereo selection in cyclic system. Reactions of cyclohexane derivatives; Hydrolysis of ester of cyclohexane carboxylic acids, Esterification Reaction of cyclohexane carboxylic acids, SN1, SN2, E1, E2, NGP, reactions. Hydride reduction of cyclohexanones to cyclohexanols, oxidation of cyclohexanols with Chromic acid, Merged substitution – elimination reaction, Reaction of 2-Aminocyclohexanol by Nitrous acid, Pinacol-pinacolone rearrangement in cyclohexanediols.

**BCHEM 0607: Quantum Chemistry & Spectroscopy (DCE) Marks 50, Credit 6**

**Unit – I: Quantum Mechanics (18 L)**

Summarization of the results of some experiments ⎯ black-body radiation, photoelectric effect, Davison and Germer experiment, Franck-Hertz experiment, identification of classical and quantum systems, Bohr’s correspondence principle with examples; postulates of quantum mechanics, properties of wave functions, operators and related theorems

Degeneracy; Schrödinger equation, energy-eigenvalue equation, expectation value, eigenvalue and spread of observation, definition of uncertainty;

Free particle system – position, momentum, energy and uncertainity relation, motion of three dimension, degeneracy, potential barrier, tunnelling

Vibrational motion of a particle, classical mechanical treatment, quantum mechanical treatment and their comparison

Rotational motion of a particle – Schrodinger equation and wave function, spherical angular coordinates, complete wave function (spherical harmonics) Physical interpretation

Elementary discussion of the H-atom solution

**Unit – II: Atomic Spectra (12 L)**

Quantum numbers, orbital and spin angular momenta of electrons, Stern-Gerlach experiment, vector atom model, term symbols (one and two optical electron systems), normal and anomalous Zeeman effect, Paschenback effect

**Unit – III: Molecular Spectroscopy (30 L)**

Electromagnetic spectrum and molecular processes associated with the regions

Rotational spectra: classification of molecules into spherical, symmetric and asymmetric tops; diatomic molecules as rigid rotors ⎯ energy levels, selection rules and spectral features, isotope effect, intensity distribution, effect of non-rigidity on spectral features

Vibrational spectra of diatomics: potential energy of an oscillator, Harmonic Oscillator approximation, energy levels and selection rules, anharmonicity and its effect on energy levels and spectral features: overtones and hot bands, vibration-rotation spectra of diatomics: origin; selection rules; P, Q and R branches

Raman spectra: origin, selection rules, rotational and vibrational Raman spectra of diatomics

NMR spectra: theory, relaxation process, instrumentation, chemical shift and shielding, factors contributing to magnitude of shielding, spin interactions ⎯ its origin, equivalent protons, qualitative idea of energy levels of AX and A2 systems, a few representative examples

Mossbauer Spectra: Origin, Chemical shift, Quadruple effect

**Recommended Books**

***Inorganic Chemistry***

R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.

R. L. Dutta, Inorganic Chemistry, Pt –II, 5th Edn, 2013, The New Book Stall, 2006.

R. Sarkar, General and Inorganic Chemistry, Pt- I, II, 2nd Edn, Books & Allied (P) Ltd, 2009.

[A. K. Das](/author/asim-k-das), Fundamental Concepts of Inorganic Chemistry, (Vol. 1-3), 2nd Edn, CBS Publisher, 2012.

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G. Wulfsberg, Inorganic Chemistry, Viva Books Private Ltd., New Delhi, 2001.

D. F. Shriver, P. W. Atkins and C. H. Langford, Inorganic Chemistry, Oxford University Press, New York, 1990.

B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.

J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Pearson Education, India, 2006.

A. Das and G. N. Mukherjee, Elements of Bioinorganic Chemistry, 2nd Edn, U. N. Dhur and Sons, Kolkata, 2002.

S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, 1st Edn, Panima Publishing, 1995.

N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn, Elsevier, India, 2005.

G. L. Miessler and D. A. Tarr, Inorganic Chemistry, 3rd Edn, Pearson Education, India, 2004.

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