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Unit-I (Inorganic Chemistry) 15h(1 hr/week)

S1-I-1. s-block elements:

General Characteristics of groups I and II elements, Diagonal relationship between Li and Mg, Be and Al 2 h

S1-I-2. p-block elements 1: 7 h

Group–13: Synthesis and structure of diborane and higher Boranes (B_4H_{10} and B_5H_{9}), Boron nitrogen compounds (B_3N_3H_6 and BN), Lewis acid nature of BX_3


S1-I-3. General Principles of Inorganic qualitative analysis 6 h

Anion analysis: Theory of sodium carbonate extract, classification and reactions of anions-CO_3^{2-}, Cl^-, Br^-, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, CH_3COO^-, NO_3^-.

Cation Analysis: Principles involved - Solubility product, common ion effect, general discussion for the separation and identification of group I individual cations (Hg_2^{2+}, Ag^+, Pb^+) with flow chart and chemical equations. Principle involved in separation of group II & IV cations.

General discussion for the separation and identification of group II (Hg^2+, Pb^{2+}, Bi^{3+}, Cd^{2+}, Sb^{2+}), III (Al^{3+}, Fe^{3+}), IV ((Mn^{2+}, Zn^{2+}) individual cations with flow chart and chemical equations. Application of concept of hydrolysis in group V cation analysis. General discussion for the separation and identification of group V individual cations (Ba^{2+}, Sr^{2+}, Ca^{2+}) with flow chart and chemical equations. Theory of flame test. Identification of Group VI cations (Mg^{2+}, NH_4^+).
Unit - II (Organic Chemistry) 15h (1 hr/week)

S1-O-1: Structural Theory in Organic Chemistry 6 h


S1-O-2: Acyclic Hydrocarbons 6 h

Alkanes – Methods of preparation: Corey-House reaction, Wurtz reaction, from Grignard reagent, Kolbe synthesis. Chemical reactivity - inert nature, free radical substitution, Halogenation example - reactivity, selectivity and orientation.

Alkenes - Preparation of alkenes (with mechanism) (a) by dehydration of alcohols (b) dehydrohalogenation of alkyl halides (c) by dehalogenation of 1,2 dihalides, Zaitsev’s rule. Properties: Addition of Hydrogen – heat of hydrogenation and stability of alkenes. trans-addition of halogen and its mechanism. Addition of HX, Markonikov’s rule, addition of H2O, HOX, H2SO4 with mechanism and addition of HBr in the presence of peroxide (anti – Markonikov’s addition). Oxidation (cis – additions) – hydroxylation by KMnO4, OsO4, trans addition- peracids (via epoxidation), hydroboration, ozonolysis – location of double bond. Dienes – Types of dienes, reactions of conjugated dienes – 1,2 and 1,4 addition of HBr to 1,3 – butadiene and Diels – Alder reaction.

Alkynes – Preparation by dehydrohalogenation of vicinal dihalides, dehalogenation of tetrahalides. Physical Properties: Acidity of terminal alkynes (formation of metal acetylides) preparation of higher alkynes, Chemical reactivity – electrophilic addition of X2, HX, H2O (tautomerism), Oxidation (formation of enediol, 1,2 diones and carboxylic acids) and reduction (Metal-ammonia reduction, catalytic hydrogenation)

S1-O-3: Alicyclic Hydrocarbons 3 h

Unit-III (Physical Chemistry) \hspace{1cm} 15 h (1 hr/week)

S1-P-1: Atomic structure and elementary quantum mechanics \hspace{1cm} 6 h
Black body radiation, heat capacities of solids, Rayleigh Jeans law, Planck’s radiation law, photoelectric effect, Limitations of classical mechanics, Compton effect, De Broglie’s hypothesis. Heisenberg’s uncertainty principle, Schrodinger’s wave equation and its importance. Physical interpretation of the wave function, significance of $\psi$ and $\psi^2$, a particle in a box, energy levels, wave functions and probability densities. Schrodinger wave equation for H-atom. Separation of variables, radial and angular functions (only equation), hydrogen like wave functions, quantum numbers and their importance.

S1-P-2: Gaseous State \hspace{1cm} 5 h

S1-P-3: Liquid State \hspace{1cm} 4 h

Unit – IV (General Chemistry) \hspace{1cm} 15 h (1 hr/week)

S1-G-1 Chemical Bonding \hspace{1cm} 11 h
Ionic solids- lattice and solvation energy, solubility of ionic solids, Fajan’s rule, polarity and polarizability of ions, covalent nature of ionic bond, covalent bond - Common hybridization and shapes of molecules.

*Molecular orbital theory*: Shapes and sign convention of atomic orbitals. Modes of overlapping. Concept of $\sigma$ and $\pi$ bonds. Criteria for orbital overlap. LCAO concept. Types of molecular orbitals- bonding, antibonding and non bonding. MOED of homonuclear diatomics - H$_2$, N$_2$, O$_2$, O$_2^-$, F$_2$ (unhybridized diagrams only) and heteronuclear diatomics CO, CN$^-$ NO, NO$^+$ and HF. Bond order, stability and magnetic properties.

S1-G-2 Evaluation of analytical data \hspace{1cm} 4 h
Significant figures, accuracy and precision. Errors-classification of errors- determinate and indeterminate errors, absolute and relative errors, propagation of errors in mathematical operations – addition, subtraction, division and multiplication (with respect to determinate errors).
References:

**Unit I**
2. Concise Inorganic Chemistry by J.D. Lee 3rd edn.
4. Vogel's Qualitative Inorganic Analysis by Svehla
8. Qualitative analysis by Welcher and Hahn.
9. Textbook of Inorganic Chemistry by R Gopalan
10. College Practical chemistry by V K Ahluwalia, Sunitha Dhingra and Adarsh Gulati

**Unit II**
5. General Organic chemistry by Sachin Kumar Ghosh.
6. Text book of organic chemistry by C N pillai

**Unit III**
1. Principles of physical chemistry by Prutton and Marron.
2. Text Book of Physical Chemistry by Soni and Dharmahara..
3. Text Book of Physical Chemistry by Puri and Sharma.
5. Physical Chemistry through problems by S.K. Dogra.
7. Elements of Physical Chemistry by Lewis Glasstone.

**Unit IV**
2. Concise Inorganic Chemistry by J.D. Lee 3rd edn.
Laboratory Course 45h (3 h / week)

Paper I Qualitative Analysis - I

I. Preparations:

1. Tetrammine copper (II) sulphate,
2. Potash alum KAl(SO$_4$)$_2$. 12H$_2$O,
3. Bis (dimethylglyoximato) nickel(II)

II. Analysis of two anions (one simple and one interfering)
B.Sc I yr CHEMISTRY
SEMESTER WISE SYLLABUS
SEMESTER II
Paper II
Chemistry - II

Unit-I (Inorganic Chemistry) 15 h (1 hr/week)

S2-I-1 p-block Elements -II 7 h

Oxides: Types of oxides (a) Normal- acidic, basic amphoteric and neutral (b) Mixed (c) sub oxide (d) peroxide (e) superoxide. Structure of oxides of C, N, P, S and Cl - reactivity, thermal stability, hydrolysis.

Oxy acids: Structure and acidic nature of oxyacids of B, C, N, P, S and Cl. Redox properties of oxyacids of Nitrogen: HNO₂ (reaction with FeSO₄, KMnO₄, K₂Cr₂O₇), HNO₃ (reaction with H₂S, Cu), HNO₄ (reaction with KBr, Aniline), H₂N₂O₅ (reaction with KMnO₄). Redox properties of oxyacids of Potassium: H₃PO₂ (reaction with HgCl₂), H₃PO₄ (reaction with AgNO₃, CuSO₄). Redox properties of oxyacids of Sulphur: H₂SO₃ (reaction with KMnO₄, K₂Cr₂O₇), H₂SO₄ (reaction with Zn, Fe, Cu), H₂S₃O₃ (reaction with Cu, Au), H₂SO₅ (reaction with KI, FeSO₄), H₂S₂O₈ (reaction with FeSO₄, KI)

Interhalogens - classification- general preparation- structures of AB, AB₃, AB₅ and AB₇ type and reactivity. Poly halides - definition and structure of ICl₂, ICl₄ and I₅⁻. Comparison of Pseudohalogenes with halogenes.

S2-I-2 Chemistry of Zero group elements 2 h

General preparation, structure, bonding and reactivity of Xenon compounds – Oxides, Halides and Oxy-halides. Clatherate compounds and Anomalous behavior of He (II)

S2-I-3 Chemistry of d-block elements 6 h


Unit - II (Organic chemistry) 15 h (1 hr/week)

S2-O-1: Aromatic Hydrocarbons 7 h

Concept of aromaticity – definition, Huckel’s rule – application to Benzenoids and Non – Benzenoids (cyclopropenyl cation, cyclopentadienyl anion and tropylonium cation).

Preapartitions: From acetylene, phenols, benzene carboxylic acids and sulphonic acids

Reactions - General mechanism of electrophilic substitution, mechanism of nitration, sulphonation, and halogenation, Friedel Craft’s alkylation (polyalkylation) and acylation. Orientation of aromatic substitution - Definition of ortho, para, and meta directing groups. Ring activating and deactivating groups with examples. Orientation – (i) activating groups: Amino, methoxy and alkyl groups. (ii) Deactivating groups - carboxy, nitro, nitrile, carbonyl and sulphonic acid & halo groups.
S2-O-2: Arenes and Polynuclear Aromatic Hydrocarbons  
Preparation of alkyl benzenes by Friedel Craft’s alkylation, Friedel Craft’s acylation followed by reduction, Wurtz-Fittig reaction. Chemical reactivity: Ring substitution reactions, side chain substitution reactions and oxidation.

Polynuclear hydrocarbons – Structure of naphthalene and anthracene (Molecular Orbital diagram and resonance energy) Reactivity towards electrophilic substitution. Nitration and sulphonation as examples.

S2-O-3: Halogen compounds  
Nomenclature and classification: alkyl (primary, secondary, tertiary), aryl, aralkyl, allyl, vinyl, benzyl. Chemical reactivity - reduction, formation of RMgX, Nucleophilic substitution reactions – classification into $S_N^1$ and $S_N^2$. Mechanism and energy profile diagrams of $S_N^1$ and $S_N^2$ reactions. Stereochemistry of $S_N^2$ (Walden Inversion) 2-bromobutane, $S_N^1$ (Racemisation) 1-bromo-1-phenylpropane explanation of both by taking the example of optically active alkyl halide. Structure and reactivity – Ease hydrolysis - comparison of alkyl, vinyl, allyl, aryl, and benzyl halides.

Unit – III (Physical Chemistry)  
S2-P-1: Solutions  

S2-P-2: Dilute Solutions & Colligative Properties  
Dilute Solutions, Colligative Properties, Raoult’s law, relative lowering of vapour pressure, molecular weight determination. Osmosis - laws of osmotic pressure, its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point. Derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties. Abnormal molar mass, Van’t hoff factor, degree of dissociation and association of solutes.

S2-P-3: Solid state Chemistry  
Unit – IV (General Chemistry) 15 h (1 hr/week)

S2-G-1: Theory of Quantitative Analysis 5 hours


Gravimetric analysis- Introduction, nucleation, precipitation, growth of precipitate, filtration and washing, drying and incineration of precipitate, coprecipitation and post precipitation. Determination of Ni^{2+}

S3-G-2: Theories of bonding in metals: 5 h

Valence bond theory, Explanation of metallic properties and its limitations, Free electron theory, thermal and electrical conductivity of metals, limitations, Band theory, formation of bands, explanation of conductors, semiconductors n-type and p-type, extrinsic & intrinsic semiconductors, and insulators.

S2-G-3: Material Science 5 h

Classification of materials- classification as metals, ceramics, organic polymers, composites, biological materials etc. The property of super conductivity of materials.

References

Unit I
2. Concise Inorganic Chemistry by J.D. Lee 3rd edn.
8. Textbook of inorganic chemistry by R Gopalan

Unit II
5. General Organic chemistry by Sachin kumar Ghosh.
6. Text book of organic chemistry by C N pillai

Unit III
1. Principles of physical chemistry by Prutton and Marron.
2. Text Book of Physical Chemistry by Soni and Dharmahara.
3. Text Book of Physical Chemistry by Puri and Sharma
4. Text Book of Physical Chemistry by K. L. Kapoor
5. Physical Chemistry through problems by S.K. Dogra.
6. Elements of Physical Chemistry by Lewis and Glasstone.
7. Material science by Kakani & Kakani

Unit IV
2. Quantitative Analysis by Day and Underwood Prentice Hall (India) VI Edn.
6. College Practical chemistry by V K Ahluwalia, Sunitha Dhingra and Adarsh Gulati
Laboratory Course

45hrs (3 h / week)

Paper II - Qualitative Analysis - II

I Semi micro analysis of mixtures

Analysis of two anions and two cations in the given mixture.

Anions: CO$_3^{2-}$, SO$_3^{2-}$, S$^2-$, Cl$^-$, Br$^-$, I$^-$, CH$_3$COO$^-$, NO$_3^-$, PO$_4^{3-}$, BO$_3^{3-}$, SO$_4^{2-}$

Cations: Ag$^+$, Pb$^{2+}$, Hg$^+$, Hg$^{2+}$, Pb$^{2+}$, Bi$^{3+}$, Cd$^{2+}$, Cu$^{2+}$, As$^{3+/5+}$, Sb$^{3+/5+}$, Sn$^{2+/4+}$, Al$^{3+}$, Cr$^{3+}$, Fe$^{3+}$, Zn$^{2+}$, Ni$^{2+}$, Co$^{2+}$, Mn$^{2+}$, Ca$^{2+}$, Sr$^{2+}$, Ba$^{2+}$, Mg$^{2+}$, NH$_4^+$
B.Sc II yr CHEMISTRY
SEMESTER WISE SYLLABUS
SEMESTER III
Paper-III
Chemistry - III

Unit-I (Inorganic Chemistry)  15 h (1 hr/week)

S3-I-1: Chemistry of f-block elements:  6 h

Chemistry of actinides- general features – electronic configuration, oxidation state, actinide contraction, colour and complex formation. Comparison with lanthanides.

S3-I-2: Symmetry of molecules  5 h

S3-I-3: Non-aqueous solvents  4 h

Unit - II (Organic chemistry)  15 h (1 hr/week)

S3-O-1: Alcohols  6 hrs
Preaparation: 1°, 2° and 3° alchols using Griganard reagent, Ester hydrolysis, Reduction of Carbonyl compounds, carboxylic acids and esters. Physical properties: H-bonding, Boiling point and Solubility. Reactions with Sodium, HX/ZnCl2 (Lucas reagent), esterification, oxidation with PCC, alk. KMnO4, acidic dichromates, conc. HNO3 and Oppenauer oxidation.

Diols: Pinacol - pinacolone rearrangement

Phenols: Preapartion: (i) from diazonium salts of anilines, (ii) from benzene sulphonic acids and (iii) Cumene hydroperoxide method.
S3-O-2: Ethers and epoxides  
2 hrs  
Nomenclature, preparation by (a) Williamson’s synthesis (b) from alkenes by the action of conc. 

S3-O-3 Carbonyl compounds  
7 h  
Nomenclature of aliphatic and aromatic carbonyl compounds and isomerism. Preparation of aldehydes & ketones from acid chloride, 1,3-dithianes, nitriles and from carboxylic acids. Special methods of preparing aromatic aldehydes and ketones by (a) Oxidation of arenes (b) Hydrolysis of benzal halides. Physical properties – absence of Hydrogen bonding. Keto-enol tautomerism, polarisability of carbonyl groups, reactivity of the carbonyl groups in aldehydes and ketones. Chemical reactivity: Addition of [a] NaHSO₃ (b) HCN (c) RMgX (d) NH₃ (e) RNH₂ (f) NH₂OH(g) PhNHNH₂ (h) 2,4DNP (Schiff bases). Addition of H₂O to form hydrate (unstable), comparison with chloral hydrate (stable), addition of alcohols - hemi acetal and acetal formation. Base catalysed reactions with mechanism- Aldol, Cannizaro reaction, Perkin reaction, Benzoin condensation, haloform reaction, Knövengeal condensation. Oxidation reactions –KMnO₄ oxidation and auto oxidation, reduction – catalytic hydrogenation, Clemmenson’s reduction, Wolf-kishner reduction, Meerwein Pondoff Verly reduction, reduction with LAH, NaBH₄. Analysis – 2,4 –DNP test, Tollén’s test, Fehling’s test, Schiff’s test, haloform test (with equations).

UNIT – III (Physical Chemistry)  
15 hr (1h / week)

S3-P-1: Phase Rule  
6 h  
Statement and meaning of the terms – Phase, Component and degrees of freedom, Gibb’s Phase 
rule, phase equilibria of one component system – water system. Phase equilibria of two-
component system – Solid-Liquid equilibria, simple eutectic – Pb-Ag system, desilverisation of 
lead. Solid solutions – compound with congruent melting point – Mg-Zn system and incongruent 
melting point – NaCl-H₂O system.

S3-P-2: Colloids & surface chemistry  
9 h  
Hardy–Schultz law, Gold number. Liquids in liquids (emulsions): Types of emulsions, 
preparation and emulsifier. Liquids in solids (gels): Classification, preparations and properties, 
General applications of colloids. 
Micelles: Classification of surface active agents. Surfactant action, micellization and micellar 
interactions, Structure of micelles – spherical and laminar. Critical micellar concentration 
(CMC). Factors affecting the CMC of surfactants. Counter ion binding to micelles. 
Adsorption: Types of adsorption, Factors influencing adsorption. Freundlich adsorption 
Unit –IV (General Chemistry)  15 h (1h/week)

S3-G-1: Nanomaterials: 3h

S3-G-2: Stereochemistry of carbon compounds 10 h

S3-G-3: Conformational analysis 2 h
Classification of stereoisomers based on energy. Definition and examples of conformational and configurational isomers. Conformational analysis of ethane, n-butane, 1,2-dichloroethane, 2-chloroethanol and methylcyclohexane
References:

Unit - I
2. Concise Inorganic Chemistry by J.D. Lee 3rd edn.
7. Textbook of Inorganic Chemistry by R Gopalan
8. College Practical chemistry by V K Ahluwalia, Sunitha Dhingra and Adarsh Gulati

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2. General Organic chemistry by Sachin Kumar Ghosh.
6. Text book of organic chemistry by C N pillai

Unit III
1. Principles of physical chemistry by Prutton and Marron.
2. Text Book of Physical Chemistry by Soni and Dharmahara.
3. Text Book of Physical Chemistry by Puri and Sharma.
5. Colloidal and surface chemistry, M. Satake, Y. Hayashi, Y.Mido, S.A.Iqbal and M.S.sethi
6. Material science by Kakani & Kakani

Unit IV
1. Text book of organic chemistry by Morrison and Boyd
2. Text book of organic chemistry by Graham solomons
3. Text book of organic chemistry by Sony
4. Text book of organic chemistry by Bruice yuranis Powla
5. General Organic chemistry by Sachin kumar Ghosh
Laboratory Course

Paper III - Quantitative Analysis - I  
45hrs (3 h / week)

Acid - Base titrations

2. Estimation of Bicarbonate in Baking Soda.
3. Estimation of Carbonate and Bicarbonate in the Mixture.
4. Estimation of Alkali content in Antacid using HCl.

Redox Titrations

1. Determination of Fe(II) using K$_2$Cr$_2$O$_7$
2. Determination of Fe(II) using KMnO$_4$ with sodium oxalate as primary standard.
3. Determination of Cu(II) using Na$_2$S$_2$O$_3$ with K$_2$Cr$_2$O$_7$ as primary standard
Unit-I (Inorganic Chemistry)  

**S4-I-1: Coordination Compounds-I**  

**7 h**


**S4-I-2: Organometallic Chemistry**  

**4 h**

Definition, nomenclature and classification of organometallic compounds. Methods of preparation, properties and applications of alkyl and aryl compounds of Li, Mg & Al. Preparation and properties of ferrocene.

**S4-I-3: Metal carbonyls and related compounds**  

**4 h**

18 valence electron rule, classification of metal carbonyls: $\text{Ni(CO)}_4$, $\text{Fe(CO)}_5$, $\text{Fe}_2\text{(CO)}_9$, $\text{Fe}_3\text{(CO)}_{12}$ and $\text{Cr(CO)}_6$. Preparation and properties of $\text{Ni(CO)}_4$.

UNIT - II (Organic chemistry)  

**15 h (1 hr/week)**

**S4-O-1: Carboxylic acids and derivatives**  

**6 h**

S4-O-2: Synthesis based on Carbanions 3 h

Acidity of \( \alpha \)-Hydrogens of withdrawing groups, structure of carbanion. Preparation of Aceto acetic ester (ethylacetoester) by Claisen condensation and synthetic application of Aceto acetic ester. (a) Acid hydrolysis and ketonic hydrolysis: Butanone, 3-Methyl 2-butanone. Preparation of (i) monocarboxylic acids ii) dicarboxylic acids (b) malonic ester – synthetic applications. Preparation of (i) substituted mono carboxylic acids and (ii) substituted dicarboxylic acids.

S4-O-3 Nitro hydrocarbons: 6 h


Unit – III (Physical Chemistry) 15 hr (1h / week)

S4-P-1: Electrochemistry & EMF 15 h

Electrical transport – conduction in metals and in electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of specific and equivalent conductance with dilution. Migration of ions and Kholrausch’s law, Arrhenius theory of electrolyte dissociation and its limitations, weak and strong electrolytes, Ostwald’s dilution law, its uses and limitations. Debye-Huckel-Onsagar’s equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf’s method for attackable electrodes. Applications of conductivity measurements: Determination of degree of dissociation, determination of \( K_a \) of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

Electrolyte and Galvanic cells – reversible and irreversible cells, conventional representation of electrochemical cells. EMF of a cell and its measurement. Computation of EMF. Types of reversible electrodes- the gas electrode, metal-metal ion, metal-insoluble salt and redox electrodes. Electrode reactions, Nernst equation, cell EMF and single electrode potential, standard Hydrogen electrode – reference electrodes (calamal electrode) – standard electrode potential, sign conventions, electrochemical series and its significance.

Applications of EMF measurements, Calculation of thermodynamic quantities of cell reactions (\( \Delta G \), \( \Delta H \) and \( K \)). Determination of pH using hydrogen electrode, glass electrode and quinhydrone electrode, Solubility product of AgCl. Potentiometric titrations.
Unit –IV (General Chemistry) 15 h (1h/week)

S4-G-1: Pericyclic Reactions 5 h
Concerted reactions, Molecular orbitals of ethene, 1,3-butadiene and allyl radical. Symmetry properties, HOMO, LUMO, Thermal and photochemical pericyclic reactions. Types of pericyclic reactions – electrocyclic, cycloaddition and sigmatropic reactions – one example each and their explanation by FMO theory.

S4-G-2: Synthetic Strategies 5 h
Terminology – Target molecule (TM), Disconnection approach – Retrosynthesis, Synthon, Synthetic equivalent (SE), Functional group interconversion (FGI), Linear, Convergent synthesis. Retrosynthetic analysis of the following molecules: 1) acetophenone 2) cyclohexene and 3) phenylethylbromide.

S4-G-3: Asymmetric synthesis 5 h
References:

Unit- I
2. 1996.
8. Textbook of Inorganic Chemistry by R Gopalan

Unit- II
2. General Organic chemistry by Sachin Kumar Ghosh.
6. Text book of organic chemistry by C N pillai

Unit III
1. Principles of physical chemistry by Prutton and Marron.
2. Text Book of Physical Chemistry by Soni and Dharmahara.
3. Text Book of Physical Chemistry by Puri and Sharma.
5. Physical Chemistry through problems by S.K. Dogra.
7. Elements of Physical Chemistry by Lewis Glasstone.
8. Industrial Electrochemistry, D. Pletcher, Chapman & Hall

Unit IV
1. Text book of organic chemistry by Morrison and Boyd
2. Text book of organic chemistry by Graham solomons
3. Fundamentals of organic synthesis and retrosynthetic analysis
4. by Ratna Kumar Kar
5. Organic synthesis by Dr. Jagadamba Singh and Dr. L.D.S. Yadav
6. Stereochemistry of organic compounds by D. Nasipuri
7. Organic chemistry by Clayden, Greeves, Warren and Wothers
8. Fundamentals of Asymmetric Synthesis by G. L. David Krupadanam
Laboratory Course

Paper IV - Quantitative Analysis - II 45hrs (3h/week)

1. Conductometry titrations:
   i) Strong acid Vs Strong base;
   ii) Weak acid Vs Strong base.
2. Potentiometry titration:
   i) Strong acid Vs Strong base;
   ii) Weak acid Vs Strong base.
3. Estimation of Nickel by back titration (Standard MgSO₄ solution will be given)
4. Estimation of Barium as Barium Sulphate
Unit-I (Inorganic Chemistry) 11 h

S5-I-1: Coordination compounds –II 9 h
Crystal field theory (CFT)- Postulates of CFT, splitting patterns of d-orbitals in octahedral, tetrahedral, square planer with suitable examples. Crystalfield stabilization energies and its calculations for various dⁿ configurations in octahedral complexes. High Spin Low Spin complexes.
Magnetic properties of transition metal complexes- para, dia, ferro, anti ferromagnetic properties, determination of magnetic susceptibility (Guoy method), spin only formula, calculations of magnetic moments.
Electronic spectra of metal complexes – colour of transition metal aqua complexes– d-d transitions.Detection of complex formation - basic principles of various methods- change in chemical properties, solubility, colour, pH, conductivity, magnetic susceptibility.
Applications of coordination compounds
Applications of coordination compounds a) in quantitative and qualitative analysis with suitable examples b) in medicine for removal of toxic metal ions and cancer therapy c) in industry as catalysts polymerization – Ziegler Natta catalyst d) water softening.

S5-I-2: Boranes and Carboranes: 2 h
Definition of clusters. Structures of boranes and carboranes- Wade’s rules, closo, nido arachno Boranes and carboranes.

Unit-II (Organic Chemistry) 11 h

S5-O-1: Amines, Cyanides and Isocyanides 7 h

Amines:
Aromatic amines – Bromination and Nitration, oxidation of aryl and 3\textsuperscript{0} Amines, diazotisation.

6. Diazonium salts: Preparation with mechanism. Synthetic importance – a) Replacement of diazonium group by – OH, X (Cl)- Sandmeyer and Gatterman reaction, by fluorine (Schiemann’s reaction), by iodine, CN, NO\textsubscript{2}, H and aryl groups. Coupling Reaction of diazonium salts. i) with phenols ii) with anilines. Reduction to phenyl hydrazines.

**Cyanides and isocyanides:**
Nomenclature (aliphatic and aromatic) structure. Preparation of cyanides from a) Alkyl halides b) from amides c) from aldoximes. Preparation of isocyanides from Alkyl halides and Amines.

2. Properties of cyanides and isocyanides, a) hydrolysis b) addition of Grignard reagent iii) reduction iv) oxidation.

**S5-O-2: Heterocyclic Compounds**  
4 h

Introduction and definition: Simple 5 membered ring compounds with one hetero atom Ex. Furan. Thiophene and pyrrole. Importance of ring systems – presence in important natural products like hemoglobin and chlorophyll. Numbering the ring systems as per Greek letter and Numbers. Aromatic character – 6- electron system (four-electrons from two double bonds and a pair of non-bonded electrons from the hetero atom). Tendency to undergo substitution reactions. Resonance structures: Indicating electron surplus carbons and electron deficient hetero atom. Explanation of feebly acidic character of pyrrol, electrophillic substitution at 2 or 5 position, Halogenation, Nitration and Sulphonation under mild conditions. Reactivity of furan as 1,3-diene, Diels Alder reactions (one example). Sulphonation of thiophene purification of Benzene obtained from coal tar). Preparation of furan, Pyrrole and thiophene from 1,4,- dicarbonyl compounds only, Paul-Knorr synthesis, structure of pyridine, Basicity – Aromaticity – Comparison with pyrrole – one method of preparation and properties – Reactivity towards Nucleophilic substitution reaction – chichibabin reaction.

**Unit-III(Physical Chemistry)**

**S5-P-1: Chemical Kinetics**  
11 h

Introduction to chemical kinetics, rate of reaction, variation of concentration with time, rate laws and rate constant. Specific reaction rate. Factors influencing reaction rates: effect of concentration of reactants, effect of temperature, effect of pressure, effect of reaction medium, effect of radiation, effect of catalyst with simple examples, order of reaction.
First order reaction, derivation of equation for rate constant. Characteristics of first order reaction. Units for rate constant. Half- life period, graph of 1\textsuperscript{st} order reaction, examples. Decomposition of H\textsubscript{2}O\textsubscript{2} and decomposition of oxalic acid.
Pseudo first order reaction, Hydrolysis of methyl acetate, inversion of cane sugar, problems.
Second order reaction, derivation of expression for 2\textsuperscript{nd} order rate constant, examples-Saponification of ester, 2O\textsubscript{3} ---\rightarrow 3O\textsubscript{2} , C\textsubscript{2}H\textsubscript{4} +H\textsubscript{2} ------\rightarrow C\textsubscript{2}H\textsubscript{6}, characteristics of second order reaction, units for rate constants, half- life period and second order plots.
Zero order reaction: derivation of rate expression, examples i) combination of H\textsubscript{2} and Cl\textsubscript{2} to form HCl, ii) thermal decomposition of HI on gold surface characteristics of Zero order reaction units of k, half-life period and graph, problems.
Determination of order of reaction: i) method of integration, ii) half life method, iii) vant-Hoff differential method iv) Ostwald’s isolation method. Problems
Kinetics of complex reactions (first order only): opposing reactions, parallel reactions, consecutive reactions and chain reactions. Problems.
Effect of temperature on reaction rate, Arrhenius equation. Temperature coefficient. Concept of energy of activation, determination of energy of activation from Arrhenius equation and by graphical method, problems. Simple collision theory based on hard sphere model explanation of frequency factor, orientation or steric factor. The transition state theory (elementary treatment).

Unit-IV (General Chemistry) 12 h

S5-G-2: Molecular spectroscopy 8 h
Introduction to electromagnetic radiation, interaction of electromagnetic rations with molecules, various types of molecular spectra.

Rotational spectroscopy (Microwave spectroscopy)
Rotational axis, moment of inertia, classification of molecules (based on moment of inertia), rotational energies, selection rules, determination of bond length of rigid diatomic molecules eg. HCl.

Infra red spectroscopy

Electronic spectroscopy:

S5-G-3: Photochemistry 4 h

References :
Unit- I
2. Concise Inorganic Chemistry by J.D. Lee 3rd edn.
4. Inorganic Chemistry Principles of structure and reactivity by James E.Huhey, E.A.

Unit- II
2. General Organic chemistry by Sachin Kumar Ghosh.

Unit III
1. Principles of physical chemistry by Prutton and Marron.
2. Text Book of Physical Chemistry by Soni and Dharmahara..
3. Text Book of Physical Chemistry by Puri, Sharma and Pattania.
4. Physical Chemistry by Atkins & De Paula, 8th Edition
8. Elements of Physical Chemistry by Lewis Glassstone.
9. Basics of Chemical Kinetics by G.L. Agarwal
10. Kinetics and mechanism of chemical transformations by Rajaram & Kuriacose

Unit IV
1. Bioinorganic Chemistry, M.N.Hughe
2. Organic spectroscopy, William Kemp
3. Text Book of Physical Chemistry by Puri, Sharma and Pattania.
4. Photochemistry by Gurdeep Raj, Goel publishing house, 5th edition

Laboratory Course:

Paper V(Organic Chemistry) 45 h (3h/w)

1. **Synthesis of Organic compounds:**
   Acetylation: Acetylation of salicylic acid, Benzoylation of Aniline.
   Aromatic electrophilic substitution: Nitration: Preparation of nitro benzene and m-dinitro benzene.
   Halogenation: Preparation of p-bromo acetanilide, Preparation of 2,4,6-tribromo phenol
   Oxidation: Preparation of benzoic acid from benzyl chloride.
   Esterification: Preparation of n-butyl acetate from acetic acid.
   Methylation: Preparation of β- naphthyl methyl ether.
Condensation: Preparation of benzilidene aniline and Benzaldehyde and aniline.
Diazotisation: Azocoupling of β-Naphthol.

2. **Thin layer Chromatography**
   Determination of Rf values and identification of organic compounds: preparation and separation of 2,4-dinitrophenyl hydrazones of acetione and 2-butanone using toluene and light petroleum(40:60)
   Separation of ortho & para nitro aniline mixtures

3. **Microwave assisted synthesis of organic compounds – DEMO (demonstration only)**
Unit I: Chromatography I 11Hrs
S5-E-A-I: Solvent Extraction- Principle, Methods of extraction: Batch extraction, continuous extraction and counter current extraction. Application – Determination of Iron (III).
Chromatography: Classification of chromatographic methods, principles of differential migration, adsorption phenomenon, nature of adsorbents, solvent systems.
Thin layer Chromatography (TLC): Advantages, preparation of plates, development of the chromatogram, Detection of the spots, factors effecting Rf values and applications.
Paper Chromatography: Principle, choice of paper and solvent systems, development of chromatogram – ascending, descending, radial and two dimensional chromatography and applications.

Unit II: Chromatography II 11Hrs S5-E-A-I: Column Chromatography- Principle, Types of stationary phases, Column packing – Wet packing technique, Dry packing technique. Selection criteria of mobile phase solvents for eluting polar, non-polar compounds and its applications.

Ion exchange chromatography: Principle, cation and anion exchange resins, its application in separation of ions.
Gas Chromatography: Theory and instrumentation (Block Diagram), Types of stationary phases and carrier gases (mobile phase).


IR Spectrophotometer: Principle, Sources of Radiations, Sampling, Block diagram of FT-IR Spectrophotometer.

b) Voltametry – three electrode assembly; Introduction to types of voltametric techniques, micro electrodes, Over potential and Polarization.

**Recommended Text Books and Reference Books**

1. Analytical Chemistry by David Krupadanam, Universities Press (India) Limited.
2. D.A. Skoog, F.J. Holler, T.A. Nieman, Principles of Instrumental Analysis, Engage earning India Ed.
Unit I: General Principles of Metallurgy and Production of Non Ferrous Metals 11 Hrs
S5-E-B-I: Pyrometallurgy: Drying and calcination, roasting, smelting, products of smelting, Hydrometallurgy: Leaching methods, leaching agents, leaching of metals, oxides and sulphaides. Separation of liquid and solid phases and processing of aqueous solutions
Electrometallurgy: Electrolysis, Refining electrolysis, electrolysis from aqueous solutions, fused-salt electrolysis
Refining processes: Chemical and physical refining processes
Production of selected non-ferrous metals (Copper, Nickel, Zinc): Properties, raw materials, production (flow charts presentations and chemical reactions involved) and uses.

Unit II: Natural and Synthetic Dyes 12Hrs
S5-E-B-II: Classification of dyes. Sources of natural dyes: Indigoid, Anthraquinone, Naphthoquinone, Benzoquinone, Flavonoid, Carotenoid and Tannin-based dyes.
Synthetic Dyes: Acidic, basic, dispersive, direct, reactive and vat dyes with examples. Extraction of natural dyes and their sustainability: The different methods for extraction of coloring materials from natural dyes. Aqueous extraction, alkali or acid extraction, microwave and ultrasonic assisted extraction, fermentation, solvent extraction, super critical fluid extraction. Drying methods. Application of natural dyes on textiles, Mordanting- types of mordanting - metallic mordants, oil mordants, Tannins and Tannic acid. Present scenario and sustainability issues in usage of natural dyes and cost considerations.

Unit III: Catalysis I 11Hrs S5-E-B-III: Homogeneous and heterogeneous catalysis -
Definition of a catalyst and catalysis. Comparison of homogeneous and heterogeneous catalysis with specific examples. General characteristics of catalytic reactions.
Phase transfer catalysis: Principle of phase transfer catalysis, classification of phase transfer catalysts. Factors influencing the rate of PTC reactions.

Unit IV: Catalysis II 11Hrs S5-E-B-IV: Enzyme catalysis- Characteristics of enzyme catalysis, Examples: (i) Invertase in inversion of cane sugar (ii) Maltase in conversion of maltose to glucose (iii) Urease in decomposition of urea and (iv) Zymase in conversion of glucose to ethanol. Factors affecting enzyme catalysis. Effect of temperature, pH, concentration and inhibitor on enzyme catalysed reactions.
Kinetics of enzyme catalysed reactions: Michaelis-Menton Equation. Mechanism of enzyme catalysed reactions. Significance of Michaelis constant \((K_m)\) and maximum velocity \((V_{\text{max}})\), Lineweaver-Burk plot.

References
5. K Venkataraman, the Chemistry of Synthetic Dyes, Volume 4, Elsevier, Technology & Engineering.
7. Physical Chemistry by Atkins and De Paula, 8\textsuperscript{th} Edn.
9. Kinetics and mechanism of chemical transformations by Rajarajm and Kuraiacose, Published by Macmillan India Ltd.

Semester - V
Laboratory Course
Experiments in Physical Chemistry-I

Paper VI (Physical Chemistry) 45hrs (3 h / w)

1. Distribution law
   a) Determination of distribution coefficient of iodine between water and carbon tetrachloride/determination of molecular status and partition coefficient of benzoic acid in Toluene and water.
   b) Determination of distribution coefficient of acetic acid between n-butanol and water.

2. Electrochemistry
   a) Determination of cell constant of conductivity cell.
   b) Determination of dissociation constant \((K_a)\) of acetic acid by conductivity measurements.

3. Colorimetry
   Verification of Beer’s law using \(\text{KMnO}_4\) and determination of the concentration of the given solution.

4. Adsorption
   Adsorption of acetic acid on animal charcoal, Verification of Freundlich adsorption isotherm.

5. Physical constants
   Surface tension and viscosity of liquids. (Demonstration Experiment)
Unit-I (Inorganic Chemistry)  11 h

S6-I-1: Inorganic reaction mechanisms  4h

S6-I-2: Bioinorganic chemistry  5h
Essential elements, Biological significance of Na, K, Mg, Ca, Fe, Co, Ni, Cu, Zn and chloride (Cl^-). Toxic metal ions As, Hg & Pb
Oxygen transport and storage – structure of hemoglobin, binding and transport of oxygen.

S6-I-3: Hard and soft acids bases (HSAB)  2h
Classification, Pearson’s concept of hardness and softness, application of HSAB principles – Stability of compounds / complexes, predicting the feasibility of reaction

UNIT - II (Organic Chemistry)  11 h

S6-O-1: Carbohydrates  6 h
Introduction: Classification and nomenclature – classification into mono, oligo and polysaccharides, into pentoses, hexoses etc., into aldoses and ketoses.
Monosaccharides: All discussion to be confined to (+) glucose as an example of aldo hexoses and (-) fructose as example of ketohexoses. Chemical properties and structural elucidation: Evidences for straight chain pentahydroxy aldehyde structure (Acetylation, reduction to n-hexane, cyanohydrin formation, reduction of Tollens’s and Fehling’s reagents and oxidation to gluconic and saccharic acids). Number of optically active, isomers possible for the structure, configuration of glucose based on D-glyceraldehyde as primary standard (No proof for configuration is required). Evidence for cyclic structure of glucose (some negative aldehyde tests and mutarotation). Cyclic structure of glucose: Proposition of cyclic structure (Pyranose structure, anomeric Carbon and anomers). Proof for the ring size (methylation, hydrolysis and oxidation reactions). Different ways of writing pyranose structure (Haworth formula and chair conformational formula). Structure of fructose: Evidence of 2 – ketohexose structure (formation of penta acetate, formation of cyanohydrin its hydrolysis and reduction by HI to give 2-Carboxy-n-hexane) Same osazone formation from glucose and fructose, Hydrogen bonding in osazones, cyclic structure for fructose (Furanose structure, Haworth formula).
Inter Conversion of Monosaccharides: Aldopentose to aldo hexose – eg: Arabinose to D-glucose, D-mannose (kiliani – Fischer method). Epimers, Epimerisation- Lobry de bruyn van Ekenstein rearrangement. Aldohexose – Aldopentose eg: D-glucose to D-arabinose by Ruff’s degradation. Aldohexose(+) (glucose) to ketohexose (−)(fructose) and Ketohexose(Fructose) to aldohexose (Glucose).

S6-O-2 Amino acids and proteins 5 h


Chemical properties: General reactions due to amino and carboxyl groups – Lactams from gamma and delta amino acids by heating peptide bond (amide linkage). Structure and nomenclature of peptides and proteins, peptide synthesis.

Unit-III (Physical Chemistry) 11 h

S6-P-1: Thermodynamics -I 11h

A brief review of - Energy, work and heat units, mechanical equivalent of heat, definition of system, surroundings. I law of thermodynamics statement- various forms mathematical expression. Thermodynamic quantities- extensive properties and intensive properties, state function, path functions energy as a state function, and exact differential. Work of expansion and heat absorbed as path function.

Expression for work of expansion, sign convention problems on I law. Heat changes at constant pressure and heat changes at constant volume. Enthalpy. Heat capacities at constant pressure and constant volume. Derivation Cp-Cv = R.


Unit-IV

S6-G-1: Proton Magnetic Resonance Spectroscopy

Principles of nuclear magnetic resonance, equivalent and non-equivalent protons, position of signals. Chemical shift, NMR splitting of signals – spin-spin coupling, representation of proton NMR spectrum – Integrations. \(^1\)H NMR spectrum of – ethyl bromide, acetaldehyde, 1,1,2-tribromo ethane, ethyl acetate and acetophenone.

S6-G-2: Mass Spectrometry

Electron Impact Mass: Basic principles, Nitrogen rule, types of ions: Molecular ion, fragment ion and isotopic ions, representation of mass spectrum, types of peaks (molecular ion, fragment and isotopic ion peaks). Determination of molecular weight Mass spectrum of ethyl chloride, ethyl bromide and acetophenone.

S6-G-3: Thermodynamics- II


References:

Unit- I


Unit- II

2. General Organic chemistry by Sachin Kumar Ghosh.

Unit III

1. Principles of physical chemistry by Prutton and Marron.
2. Text Book of Physical Chemistry by Soni and Dharmahara..
4. Physical Chemistry by Atkins & De Paula, 8th Edition
8. Elements of Physical Chemistry by Lewis Glasstone.
9. Thermodynamics by Rajaram

Unit IV
2. Organic Spectroscopy, William Kemp
3. Principles of physical chemistry by Prutton and Marron.
4. Text Book of Physical Chemistry by Soni and Dharmahara.
5. Text Book of Physical Chemistry by Puri, Sharma and Pattania.
6. Thermodynamics by Rajaram

Semester - VI
Laboratory Course
Paper VII
Qualitative and Spectral Analysis of Organic Compounds: 45hrs (3 h/w)

Qualitative analysis: Identification of an Organic compound through the functional group analysis, determination of melting points/boiling points, functional group tests and preparation of suitable derivatives of the following:

Carboxylic acids, phenols, amines, urea, thiourea, carbohydrates, aldehydes, ketones, amides, nitro hydrocarbons, ester and naphthalene.

Spectral analysis Determination of structures from combined spectral data (IR, ¹H-NMR and Mass): Minimum of five problems.
Unit- I: Introduction and Terminology  


Terminology in Medicinal Chemistry: Drug, Pharmacology, Pharmacophore, Pharmacodynamics, Pharmacokinetics, metabolites, anti metabolites and therapeutic index.

Drugs: Nomenclature: Chemical name, Generic name and Trade names with examples; Classification: Classification based on structures and therapeutic activity with examples.


Unit-II: Enzymes and Receptors 11Hrs  


Structure – activity relationships of drug molecules, explanation with sulfonamides.

Unit- III: Synthesis and Therapeutic Activity of Drugs 12Hrs  

S6-E-A-III: Introduction, synthesis and therapeutic activity of :

Chemotherapeutics: Sulphanilamide, dapsone, Pencillin-G (semi synthesis), Chloroquin, Isoniazid, Cisplatin and AZT.

Drugs to treat metabolic disorders: Anti diabetic - Tolbutamide; Antiinflammatiory – Ibuprofen; Cardiovascular- Glyceryl trinitrate; Antipyretic (paracetamol, aspirin) and Antacid-Omeprazole.


Unit- IV: Molecular Messengers and Health Promoting Drugs 11Hrs  


Health promoting drugs: Introduction, sources. Deficiency disorders and remedy of Vitamins A,B, C, D, E K and micronutrients – Na, K, Ca, Cu, Zn and I.

Reference books
Unit I: – Pesticides  
S6-E-B-I: Introduction, Definition, classification of pesticides based on use (target). Toxicity and chemical structure with examples. Adverse effects of pesticides and its impact on environmental pollution. 

Synthesis, technical manufacture and uses of representative pesticides in the following classes: Organochlorines (Cypermethrin); Organophosphates (Parathion); Carbamates (carbaryl); Quinones (Chloranil), Anilides (Alachlor).

Pesticide formulations: Dusts, Granules, Wettable powders, Emulsions and Aerosols. 

Biopesticides: Introduction: Potential pesticidal plants of India, Role of Neem in plant protection-constituents, Azadirachtin and its role in pest control, Structure and mode of action of Pyrethrins (pyrethin-1) and Pyrethroids (permethrin) and nicotinoids (Imidacloprid).

Unit II: – Fertilizers  
S6-E-B-II: Introduction: (need of fertilizers), functions of essential plant nutrients (N, P, K), Classification formula and uses of fertilizers:

Nitrogenous fertilizers: Ammonium nitrate, Urea, Calcium Cyanamide, Calcium Ammonium Nitrate, Sodium Nitrate, Ammonium Chloride and their uses. 
Phosphate fertilizers: Normal super phosphate, Triple Super Phosphate, Ammonium Phosphate and their uses. 
Potassium fertilizers: Potassium chloride, potassium nitrate, potassium sulphate and uses. 
Complex fertilizers: Diaammonium Phosphate and mixed fertilizers their uses. Manufacture of urea and Super phosphate of lime and their reactions in the soil. 
Biofertilizers – Introduction, definition, classification, Rhizobium, Azatobactor, Azospirillium, Azolla, Blue Green Algae, Vermicomposting and uses. 

Organic farming: The principal methods, crop rotation, green manures and compost, biological pest control, and mechanical cultivation and uses.

Unit III: Energy Sources and Coal 11Hrs.  
S6-E-B-III: 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.

Unit IV: Petroleum, Petrochemical Industry and Lubricants 11Hrs.  
S6-E-B-IV: Petroleum and Petrochemical Industry: 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 of 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 and their uses.

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

**Reference books**
1. N. N. Melnikov, Chemistry of pesticides; Springer-Verlag- Technology & Engineering (2012).
4. A. K. Kolay Manures and Fertilisers; Published by Atlantic (2007).

**Semester - VI**

**Laboratory course**

**Experiments in Physical Chemistry-II**

**Paper VIII (Physical Chemistry) 45hrs (3 h/w)**

1. **Kinetics**

   a) Determination of specific reaction rate of the hydrolysis of methyl acetate catalyzed by hydrogen ion at room temperature.

   b) Determination of rate of decomposition of hydrogen peroxide catalyzed by FeCl₃.

2. **Electrochemistry**

   **A. Potentiometry**

   a) Determination of redox potential of Fe²⁺/Fe³⁺ by potentiometric titration of ferrous ammonium sulphate vs. potassium dichromate.

   b) Precipitation titration of KCl vs. AgNO₃ - Determination of given concentration of silver nitrate.

   **B. pHmetry:**

   a) pH metric titration of strong acid (HCl) vs. strong base- Determination of the concentration of the given acid.
b) pH metric titration of weak acid (acetic acid) with strong base (NaOH). - Determination of acid dissociation constant ($K_a$) of weak acid.

3. Conductometry:

Determination of overall order: Saponification of ethyl acetate with NaOH by conductance measurements.