RTM NAGPUR UNIVERSITY NAGPUR

SEMISTER PATTERN SYLLABUS

(Implemented from session 2017-18)

SUBJECT CHEMISTRY

B.Sc. –I, Semester - I

CH – 101: Paper- I (Inorganic Chemistry)

Unit-I **(7.5 Hrs)**

(A) Atomic structure-Idea of de-Broglie matter Waves, Heisenberg's uncertainty principle. Schrodinger wave equation, significance of Ψ and Ψ2, Quantum numbers, shapes of s, p, and d orbitals, Aufbau principle, Pauli's exclusion principle and Hund's rule of maximum multiplicity. Electronic Configuration of elements and ions (Z = 1 to 30)

(B) Periodic Properties: Atomic and ionic radii, ionization energy, electron affinity and electronegativity- Definition, trends in periodic table. Factors affecting ionization potential. Pauling's and Muliken's scale of electronegativity. Effective nuclear charge and Slater's rule with some numericals.

Unit-II **(7.5 Hrs)**

(A) Covalent Bond: Valence Bond Theory, Formation of Hydrogen molecule with Potential energy diagram Limitations of VBT, directional characteristics of covalent bond, overlap criterion and bond strength. Bond energy, bond length, Bond order and Bond angle. Various types of hybridization involving s, p, d orbitals and shape of inorganic molecules.

(B)Ionic solids: Ionic structures with respect to NaCl and CsCl, Lattice energy and Born- Haber cycle with numericals. Solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajans rule.

Unit – III **(7.5 Hrs)**

(A) s- block elements- Electronic configuration, Comparative study with respect to atomic and ionic radii, Ionization potential, reducing properties. Diagonal Relationships (Li-Mg). Hydrogen bonding .Classification and effect of Hydrogen bonding on viscosity, solubility, M.pt. and B.pt.

(B) Chemistry of Noble Gases: Chemical properties of the noble gases, Preparation, chemical properties, structures, bonding and applications of Xenon fluorides (XeF_2, XeF_4, XeF_6). Structure and bonding in $XeOF_2$ and $XeOF_4$

Unit- IV **(7.5 Hrs)**

(A) p-block elements – Introduction to p-block elements. Comparative study of groups 15, 16 and 17 with respect to their Atomic and ionic radii, Ionization potential, electron affinity, electronegativity, redox properties and oxidation state. Diagonal relationship (B-Si).

(B) **Hydrides:** Comparative study with respect to structure of NH_3, PH_3, AsH_3 and SbH_3.
Oxides: Structure of P_2O_3 ,P_2O_5
Oxyacids of Phosphorous: Structure of H_3PO_3 and H_3PO_4
Peroxyacids of sulphur: Preparation and structure of Caro's and Marshall's acids.
Hydrides of boron: Structure and bonding of diborane, structure of borazine.

CH – 102: Paper- II (Physical Chemistry)

UNIT-I: Thermodynamics (7.5 Hrs)

(A) Definitions of some common thermodynamic terms: system, surrounding etc. Types of systems (closed, open & isolated). Homogeneous and Heterogeneous systems, extensive and intensive properties, thermodynamic processes (isothermal, adiabatic, isobaric, isochoric, cyclic, reversible & irreversible). State & path functions and their differentiation, concept of heat & work.

(B) Statements of first law of thermodynamics, definition of internal energy & enthalpy. Heat capacity, heat capacity at constant volume and at constant pressure & their relationship. Joule-Thomson experiment, Joule-Thomson coefficient & inversion temperature, calculations of w, q, ΔE & ΔH in isothermal & adiabatic expansion of ideal gases for reversible process.

(C) Thermo chemistry: Standard states, Standard enthalpy of formation. Hess's law of constant heat of summation & its applications. Heat of reaction, relation between heat of reaction at constant volume and constant pressure. Average bond energy, bond dissociation energy and its calculations from thermo chemical data. Numerical problems.

Unit-II Gaseous State. (7.5 Hrs)

A) Postulates of kinetic theory of gases, derivation of kinetic gas equation, deduction of various gas laws from kinetic gas equation (Boyle's, Charle's, Avogadro's, Graham's, Dalton's law and ideal gas equation). Qualitative discussion of the Maxwell- Boltzmann distribution of molecular velocities. Effect of temperature on molecular velocities. Different types of molecular velocities (most probable, R.M.S. and average and expressions for them), their inter relationships. Definitions of collision diameter, collision number and Mean free path.

(B) Ideal gas and real gases, Difference between an ideal and real gases. Deviations from ideal behavior. Explanation of the terms – Compressibility factors and Boyle temperature. Causes of deviation from ideal behaviors. Vander Wall's equation of state, explanation of behavior of real gases by Van der Waal's equation. Andrew's experiment on critical phenomenon of isotherms of CO2. Continuity of states. The isotherms of Van der Waal's equation, Relationship between critical constants and Van der Wall's constants. Reduced equation of state and law of corresponding states. Numerical problems

Unit- III Liquid State (7.5 Hrs)

A) Intermolecular forces, structure of liquids (a qualitative description), structural differences between solids, liquids and gases, liquid crystals, Difference between liquid crystals, solids and liquids. Classification, structure of Nematic and Cholesteric phases. Thermography and seven segment cell.

B) Properties of liquid:

i) Surface tension: Explanation, measurement of surface tension, Capillary rise method and drop number method, Parachor value and its application.

ii) Viscosity: Explanation, coefficient of viscosity, Effect of temperature on Viscosity, relative viscosity, specific viscosity, intrinsic viscosity and reduced viscosity. Method of determination of viscosity (Ostwald viscometer method).

iii) Refractive index: Definition. Method for determination of refractive index (Abbe's Refractometer).specific refraction, molar refractions. Numerical problems.

Unit- IV Surface Chemistry and Catalysis: (7.5 Hrs)

A) Adsorption- Introduction, Factors affecting adsorption of Gases by Solids, Difference between physical and chemical adsorptions. Adsorption Isotherms: Freundlich Adsorption Isotherm, Langmuir Adsorption Isotherm, B.E.T. Equation (no derivation), Application of B.E.T. Equation in Determination of Surface Area of Adsorbent, Application of Adsorption.

B) Catalysis: - Introduction, Positive and negative catalysis. General characteristics of catalyst. Promoters & Inhibitors. Action of catalytic promoters and Inhibitors. Homogeneous & Heterogeneous Catalysis, Enzyme catalysis, auto catalysis. Kinetics of Enzyme Catalyzed Reactions- Machaelis-Menten Equation. Numerical problems.

CH-103: Laboratory Course

Practical- I (Inorganic Chemistry): Semi micro Qualitative Analysis

Qualitative analysis of inorganic salt mixture containing two acidic radicals of different group and two basic radicals of same groups. (At least six mixtures to be analyzed)

Practical- II (Physical Chemistry)

1) To determine the heat of solution of potassium nitrate calorimetrically.
2) To determine the heat of ionization of acetic acid calorimetrically
3) Determination of viscosity of unknown liquid by Ostwald viscometer.
4) To determine the percentage composition of given binary mixture (Ethanol-water) by viscosity method.
5) Determination of surface tension of a given liquid by drop number method (Stalagmometer method)
6) To compare cleansing power of two samples of detergent.
7) To determine refractive index, specific and molar refraction of given liquids by Abbe's refractometer.
8) To study the adsorption of oxalic acid on activated charcoal and verify the Freundlich adsorption isotherm.

(At least six experiments to be performed)

B.Sc. –I, Semester - II

CH – 201: Paper- I (Organic Chemistry)

Unit - I **(7.5 Hrs)**

A) Structure and Bonding: Hybridization in case of Methane, Ethane, Ethylene and Acetylene. Bond lengths, bond angles and bond energies. Elementary ideas of Inductive effect, Electromeric effect. Resonance effect, Hyperconjugation (definition and examples). Hydrogen bonding in organic compounds (with reference to alcohol) and its consequences.

B) Mechanism of Organic Reactions: Homolytic & heterolytic bond fission with examples. Electrophiles & nucleophiles - definition and example both neutral and charged. Types of organic reactions - addition, substitution, elimination, rearrangement. Reactive intermediates – Definition: carbocations, carbanions, free radicals, carbenes, formation, geometry (orbital structure), stability.

Unit - II **(7.5Hrs)**

Stereochemistry of Organic Compounds: Concept of isomerism. Types of isomerism with suitable examples. Optical isomerism-elements of symmetry, molecular chirality, enantiomers, stereogenic centre (lactic acid as example). Optical activity, chiral and achiral molecules with two stereogenic centres (Tartaric acid) diastereo-isomers, meso-compound. Resolution of enantiomers biological and chemical methods. Inversion, retention and recemisation. Asymmetric synthesis. Relative and absolute configuration, sequence rules- D & L and R & S system of nomenclature.

Geometrical isomerism: E & Z system of nomenclature, geometric isomerism in maleic acid, fumaric acid and 2-butene.

Conformational isomerism: Conformational analysis of ethane and n-butane.

Newman's projection and sawhorse formulae. Difference between configuration and conformation.

Unit - III **(7.5 Hrs)**

A) Alkanes: IUPAC nomenclature of branched and unbranched alkanes. Alkyl group, methods of formation (Ethane) - Wurtz reaction, Kolbe's reaction, decarboxylation of carboxylic acid. Physical properties and chemical reactions of alkanes: halogenation, nitration, sulphonation, isomerization, cyclization, aromatization, pyrolysis, cracking and oxidation. L. P. G., Octane number. Mechanism of free radical chlorination of methane.

Cycloalkanes: Nomenclature. Baeyer's strain theory and its limitations. Ring strain in small rings cyclopropane and cyclobutane. Theory of stainless rings. Conformational analysis of cyclohexane, axial and equatorial bonds.

B) Alkenes: Nomenclature of alkenes, methods of formation (ethylene & propylene) – dehydrogenation of alkane, dehydrohalogenation of alkyl halides, dehydration of alcohol, dehalogenation of dihalides. Chemical reactions of alkenes (ethylene and propylene) - hydroboration, oxidation $KMnO_4$, HIO_4, Epoxidation, Ozonolysis, Hydroxylation, Polymerization, Substitution in allylic position of alkenes. Markownikoff's Rule and peroxide effect. Ionic Mechanism of addition of Br_2 to ethene and HBr to propene Free radical mechanism of addition of HBr to propene.

Unit - IV **(7.5 Hrs)**

A) Dienes: Nomenclature and classification of dienes. Methods of formation of 1, 3 - butadiene. Chemical reactions of butadiene - 1, 2 and 1, 4 additions, Diels-Alder reaction.

Alkynes: Nomenclature, structure and bonding in Alkynes. Methods of formation of acetylene from - calcium carbide, dehydrohalogenation of dihalides .Chemical reaction - hydroboration, oxidation ,metal ammonia reduction & polymerization. Oxyacetylene flame. Acidity of alkynes.

B) Aromatic compounds and Aromaticity: Nomenclature of Benzene derivatives. Structure of benzene - Molecular formula and Kekule structure, Resonance structure, MO picture. Huckel rule – aromaticity, aromatic ions (cyclopentadienyl anion and cycloheptatrienyl cation). Aromatic electrophillic substitution mechanism with energy profile diagram (e.g. nitration and sulphonation).

CH – 202: Paper- II (Physical Chemistry)

UNIT- I: Thermodynamics **(7.5 Hrs)**

(A) Second law of thermodynamics : Need for second law of thermodynamics, statements of second law of thermodynamics, Carnot's cycle and its efficiency, Carnot theorem, thermodynamic scale of temperature, concept of entropy, entropy change in reversible and irreversible processes, entropy change of the universe, entropy change for an ideal gas with change in P, V & T, entropy change during physical change, physical significance of entropy, entropy as criteria of spontaneity & equilibrium of a process.

(B)Free energy functions: Work function (A) and Gibb's free energy (G), Variation of work function with T and V, variation of Gibb's free energy with T and P. A and G as criteria for spontaneity and equilibrium of a process. Gibb's – Helmholtz equation & its applications.

(C) Chemical equilibrium: Law off mass action, law of chemical equilibrium, relationship between k_p and k_c. Van't-Hoffs reaction isotherm, relation between standard free energy change & equilibrium constant, effect of temperature on equilibrium constant (reaction isochor), integrated form of Van't Hoff equation. Numerical problems.

UNIT-II: Phase Equilibra **(7.5 Hrs)**

(A) Phase rule: Statement and meaning of the terms: Phase, component and degree of freedom, Derivation of Gibb's Phase rule. Applications of phase rule to one component system i) water

system, ii) Sulphur system. Need of reduced phase rule equation. Application of phase rule to two component system: Lead silver system, Pattinson's process for desilverization of lead.

(B) Liquid-Liquid mixtures: Raoults law of ideal solutions, ideal liquid mixtures, Henry's law, non-ideal systems, azeotropes (HCl - H_2O & C_2H_5OH - H_2Osystem). Partial miscible liquids, lower & upper consolute temperature, (phenol-water system, trimethylamine-water and nicotine-water systems), effect of impurity on consolute temperature, Nernst distribution law, conditions for the validity of Nernst distribution law (Association and dissociation). Numerical problems.

UNIT-III: Nuclear chemistry and molecular structure: (7.5 Hrs)

A) Nuclear chemistry Composition of Nucleus, Mass defects, Nuclear binding energy, Average binding energy per nucleon, explanation of nuclear stability on the basis of graph between average binding energy per nucleon and atomic mass number.

Nuclear reactions: Fission and fusion.

Nuclear models: Shell model and Liquid drop model, comparison between them. Bohr-Wheeler theory. Applications of radioisotopes in medicine, agriculture, carbon dating and structure determination.

(B) Molecular structure:

Dipole moment, polar and non-polar covalent bond, Electrical polarization of molecules, Orientation of dipoles in an electric field. Determination of dipole moment. Application of dipole moment to %age ionic character, Geometry of molecules, study of geometrical isomers and substituted benzene molecules. Numerical problems.

UNIT-IV: Chemical Kinetics (7.5 Hrs)

(A) Rate of reaction, factors affecting the rate of a reaction (concentration. temperature, pressure, solvent, light and catalyst). Order and molecularity of reaction. Reactions of zero order. Mathematical expression for rate constant of first and second order reactions, their characteristics. Pseudo unimolecular reactions. Methods of determination of order of reaction: Integration method, differential method, graphical method, half life period and isolation method.

(B) Theories of chemical kinetics: concepts of activation energy. Arrhenius equation, Effect of temperature on rate of reaction.

Collision theory of bimolecular reactions (hard sphere model). Transition state theory (equilibrium hypothesis). Expression for rate constant based on equilibrium constant and thermodynamic aspects. Lindeman's theory of unimolecular reactions. Numerical problems.

CH-203: Laboratory Course

Practical I (Organic Chemistry):

A) Qualitative Analysis: Element detection(N, Cl , Br, F & S),Identification of functional groups (-COOH, Phenolic –OH,_-CHO, Aromatic -NH2, -CONH2) ,determination of M.P & B.P.

B) Preparation: i) Hydrolysis : Preparation of Benzoic acid from Benzamide

ii) Oxidation: Preparation of Benzoic acid from Benzaldehyde

iii) Bromination of Phenol

Practical II (Physical Chemistry):

1. To determine the integral heat of solution of a salt at two concentrations and hence determine the integral heat of dilution.
2 To determine the solubility of benzoic acid at different temperatures and to determine heat of solution of benzoic acid.
3. To construct the phase diagram of three component system (Acetic acid-chloroform-water)
4. To determine the critical solution temperature of two partially miscible liquids (phenol-water systems).
5. To study the distribution coefficient of Iodine between Water and Carbon tetrachloride/Kerosene
6. To determine molecular state of benzoic acid in benzene by distribution method.
7. To determine the rate constant of hydrolysis of methyl acetate in presence of acid.
8. To determine the specific reaction rate of hydrolysis of ethyl acetate catalyzed by NaOH (saponification)

(At least six experiments to be performed)

B.Sc. –II, Semester - III

CH – 301: Paper- I (Inorganic Chemistry)

(2018-2019)

Unit – I: **(7.5 Hrs)**

(A) Valence Shell Electron pair repulsion (VSEPR) **Theory**: Structure with respect to H_2O, NH_3, NH_4^+ ClF_3, SF_4, ICl_4^-.

Preparation, properties and structure of Interhalogen compounds. Polyhalides (Structure of I_3^-, I_5^-, ICl_4^-)

(B) MO theory: LCAO approximation, wave equation for molecular orbitals. Difference between bonding and anti bonding MO in terms of energy and electron density distribution curves, order of energy levels in MO. Molecular Orbital diagrams for homonuclear diatomic molecules of elements (with Z = 1 to 9). Concepts of nonbonding MO in HF molecule. Coulson's MO diagram of CO and NO diatomic molecule.

Unit- II: **(7.5 Hrs)**

A) Chemistry of elements of first transition series:

Characteristic properties of the elements of first transition series with reference to their: Electronic configuration, Atomic and ionic radii, Ionization potential, Variable oxidation states, Magnetic properties, Colour, Complex formation tendency and catalytic activity.

(B) Chemistry of elements of second and third transition series:

Electronic configuration of 4d and 5d transition series .Comparative treatment with their 3d-analogous (Group Cr-Mo-W, Co-Rh-Ir,) in respect of oxidation states and magnetic behavior.

Unit III: **(7.5 Hrs)**

A) Errors in Chemical Analysis:

i) Random and Systematic errors, Explanation of terms: Accuracy and Precision, Uncertainty, Absolute and Relative errors, Mean , Median, Average and Standard deviations, Significant figures, numerical problems.

ii) Statistical Test of Data: Q-test, 2.5d and 4d Rules for rejection of data. Numerical problems.

B) Non-aqueous solvents:

Classification of solvents and characteristic reactions(acid base, redox & precipitation reactions) in Non-aqueous solvents with reference to i)Liquid Ammonia and ii) Liquid Sulphur dioxide.

Unit – IV: **(7.5 Hrs)**

A) Chemistry of Lanthanides:

Position in periodic table, electronic configuration, Oxidation states, Atomic and ionic radii, Lanthanide contraction and its consequences, Complex forming tendency. Occurrence and separation of lanthanides (ion exchange and solvent extraction).

B) Chemistry of Actinides:

Position in periodic table, electronic configuration, Oxidation states, Atomic and ionic radii. Actinide contraction.

CH-302: Paper- II (Organic Chemistry)

Unit –I **(7.5 Hrs)**

Orientation: Activating (–OH, $–NH_2$) & deactivating (–Cl, $–NO_2$ –COOH) substituent's, their orientation and directive influence on further electrophilic substitution, o/p ratio. Methods of formation and chemical reactions of alkyl benzene (Toluene) and biphenyl.

Alkyl halides: Nomenclature, classification, methods of formation, chemical reactions. Mechanism of nucleophilic substitution reactions of alkyl halides SN^1 and SN^2 with energy profile diagrams.

Polyhalogen compounds: Chloroform and carbon tetrachloride – formation and chemical reactions.

Nuclear and side chain halogen derivatives of benzene (Aryl halides): Chlorobenzene and benzyl chloride preparation and reactions. Relative reactivity of alkyl halides vs aryl halides. Synthesis and uses of DDT and BHC.

Unit – II **(7.5 Hrs)**

A) Alcohols: Classification and nomenclature,

Dihydric alcohols: Nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage ($Pb(Oac)_4$ and HIO_4) and Pinacol – pinacolone rearrangement with mechanism.

Trihydric alcohols : Nomenclature and methods of formation of Glycerol from (i) Propene and (ii) Hydrolysis of oils and fats, chemical reactions of glycerol - with oxalic acid at two different temperatures, HI, HNO_3, dehydration.

(B) **Phenols:** Nomenclature, structure and bonding. Preparation of phenols from cumene, chlorobenzene (Dows and Raschig process) and diazonium salts. Physical properties and acidic character, Resonance stabilization of phenoxide ion, Reactions of phenols, Electrophilic aromatic substitution, acetylation and carboxylation, Claisen rearrangement, Gatterman synthesis, Reaction Mechanism of i) Fries Rearrangement,ii) Reimer-Tiemann reaction.

Unit – III **(7.5 Hrs)**

Aldehydes and ketones: Nomenclature, structure of the carbonyl group, synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides and ketones from nitriles.

Mechanism of nucleophilic additions to carbonyl group with particular emphasis on Benzoin, aldol, Perkin and Knoevenagel condensation. Wittig reaction, Mannich reaction, oxidation of

aldehydes (by $KMnO_4$,Tollen's reagent and Fehlings solution), Baeyer-Villiger oxidation of Ketones, Cannizaro reaction, (with mechanism) ,MPV, Clemmensen, Wolf-Kishner, LiAlH4 and NaBH4 reductions.

Unit IV **(7.5 Hrs)**

A) Carboxylic Acids: Nomenclature, structure & bonding. Physical properties, acidity of carboxylic acids, effect of substituent's on acid strengths , preparation of carboxylic acids(from Grignard Reagent and cyanides), Reactions of carboxylic acids, Hell-Volhard-Zelinsky reactions. Reduction of carboxylic acids, Mechanism of decarboxylation with soda lime. Methods of formation and chemical reactions of unsaturated monocarboxylic acids (crotonic acid and cinnamic acid).

Dicarboxylic acids: Methods of formation of succinic acid from ethylene dibromide and Phthalic acid from o-xylene. Effect of heat and dehydrating agents. (Succinic acid, Phthalic acid).

(B) Carboxylic acid derivatives : Structure & nomenclature of acid chlorides, esters, amides and acid anhydrides. Interconversion of acid derivatives by nucleophilic acyl substitution. Preparation of carboxylic acid derivatives, Chemical reactions, Mechanism of esterification and hydrolysis (acidic and basic).

CH- 303: Laboratory Course

Practical-I (Inorganic Chemistry):

Volumetric Analysis (All 5 Expts. to be performed)

Preparation of standard solution by weighing is compulsory

1) Estimation of Fe(II) by dichromate using internal indicator.
2) Determination of acetic acid in commercial vinegar using NaOH
3) Determination of alkali content in antacid tablet using HCl
4) Determination of Zn by complexometric titration with EDTA
5) Determination of total Hardness of water (permanent and Temporary) by EDTA

Practical- II(Organic Chemistry):

Complete analysis of simple organic compound involving following steps :-

(i) Preliminary examination ii)Detection of elements iii)Detection of functional group iv)Determination of M.P. / B.P. v) Preparation of derivative and its M.P./B.P. vi)Performance of specific test if any

B.Sc. –II, Semester – IV

CH – 401: Paper- I (Inorganic Chemistry)

Unit-I: (7.5 Hrs)

Coordination compounds:

Distinction among simple salts, double salts and coordination compounds. Werner's Coordination theory and its experimental verification. Sidgwicks electronic interpretation, EAN rule with examples, Nomenclature of Coordination compounds. Chelates: Classification and their application, Valence Bond Theory of transition metal complexes.

Unit- II: (7.5 Hrs)

A) Isomerism in coordination compounds:

Structural isomerism and Stereoisomerism in coordination compounds with respect to C.N. 4 & 6

B) Oxidation and reduction:

Concept of oxidation and reduction. Balancing of redox reactions by Electron method numericals. EMF series and its applications. Use of redox potential data: Analysis of Redox cycle, redox stability in water, Latimer diagram of Chlorine and Oxygen, Construction and explanation of Frost diagram. Frost diagram of Nitrogen and Oxygen. Pourbaix diagram of Iron.

Unit- III: 7.5 Hrs

A) Colorimetery and Spectrophotometery: (7.5 Hrs)

Principles of photometery: Beer-Lamberts Law, derivation and deviation(Numericals). Types of colorimeter and spectrophotometer with simple schematic diagrams. Application of colorimeter and spectrophotometer in quantitative analysis with reference to estimation of Cu(II) as Cu-ammonia complex.

B) Separation Techniques:

a) Chromatography: Classification, Principle, Technique and Application of Paper and Column Chromatography.

b) Ion- Exchange: Types of ion exchange resins, Equilibria and ion exchange capacity, Application in separation of binary mixtures.

c) Solvent Extraction: Principle and Classification, Factors influencing extraction and application in chemistry.

Unit- IV Inorganic Polymers: (7.5 Hrs)

Silicones: Introduction, Nomenclature, preparation, properties and uses, General introduction to Silicon oils, Silicone Elastomers and Silicon Resins

Phosphonitrilic halide polymers: Introduction, Preparation, properties and uses. Structure and bonding in $(NPCl_2)_3$ and $(NPCl_2)_4$

CH – 402: Paper- II (Physical Chemistry)

Unit-I Solid State (7.5Hrs)

Solids and their classification, Difference between crystalline and amorphous solids, classification of crystalline solids. Laws of crystallography: Law of constancy of interfacial angles, Law of rationality of indices, Law of symmetry, elements of a crystal.

Space lattice, Unit cell, Bravais lattices, crystal systems, identification of crystal planes, interplanner distance in cubic systems, X-ray diffraction by crystal, derivation of Braggs' equation. Determination of crystal structure of NaCl, KCI and CsCl, Laue's method and powder method.

UNIT –II: Electrochemistry (7.5Hrs)

A) Electrical transport : Conductance in metals (electronic) & in electrolyte solutions (ionic conductance), specific, equivalent and molar conductance, measurement of electrolytic conductance, variation of equivalent, specific & molar conductance with dilution, Kohlrausch's law, Arrhenius theory of electrolyte dissociation & its limitation, Ostwald's dilution law, validity and importance of Ostwald's dilution law.

Debye-Huckel theory (elementary treatment).Relaxation effect, Electrophoretic effect, Onsagar equation.

B) Transport number, determination of transport number by Hittorfs method & moving boundary method, factors affecting transport number of ions, relation between ionic conductance & transport number. Applications of Kohlrausch's law & conductance measurements: determination of equivalent conductance at infinite dilution for weak electrolytes, determination of degree of dissociation, determination of solubility and solubility product of sparingly soluble salts. Conductometric titrations (Acid-base & precipitation titrations). Numerical problems.

Unit-III: Spectroscopy (7.5 Hrs)

A) Rotational Spectroscopy: Rotational spectra of diatomic molecules, Energy levels of rigid rotor. Selection rule for transition between energy levels. Expression for wave number of spectral lines in terms of rotational constant (B) and rotational quantum number (J). Intensity of spectral lines. Types of molecules showing rotational spectra. Application of rotational spectra for determination of moment of inertia and bond length. Introduction to non-rigid rotor.

B) Vibrational Spectra:

Vibrational energy levels of simple harmonic oscillator, selection rules. Types of molecules showing vibrational spectra. Vibrational energy level of anharmonic oscillator, selection rule, idea of overtones. Vibrational – Rotational spectra. P,Q and R branches of the vibrational – rotational spectra. Structural information from infrared spectra. Numerical problems.

Unit IV: Quantum Chemistry I **(7.5 Hrs)**

A) Failure of classical mechanics, Explanation of Black body radiation, Photoelectric effect, and heat capacity of solids on the basis of classical mechanics. Bohr's model of Hydrogen atom, spectrum of hydrogen atom, Plank's quantum theory. De Broglie's hypothesis (Derivation and experimental proof). Heisenberg's uncertainty principle (Explanation and experimental proof).

B) Introduction to wave functions (Ψ), Schrodinger wave equation. Eigen values and Eigen functions, well behaved wave functions. Interpretation of wave function (Ψ) and its square (Ψ_2), Normalized and orthogonal wave functions. Postulates of quantum mechanics, Derivation of Schrodinger wave equation from postulates of quantum mechanics. Application of Schrodinger wave equation for a particle in one dimensional box and three dimensional box. Concept of degeneracy. Numerical problems.

CH-403: Laboratory Course

Practical-I (Inorganic Chemistry):

A) Preparation of following complexes and Comments on its VBT structure, magnetic properties and colors

a) $[Cu(NH_3)_4(H_2O)_2]SO_4$ b) $[Ni(NH_3)_6]SO_4$ c) Trans $[Co(NH_3)_4Cl_2]Cl$

d) $K_3[Fe(C_2O_4)_3].H_2O$

B) Chromatographic separation of binary mixtures(at least Two) containing Cu(II), Co(II) and Ni(II) ions by paper chromatography and determination of Rf values.

Practical-II (Physical Chemistry):

1. To construct various crystal lattices.
2. To determine the strength of the given acid (HCl or CH_3COOH) conductometrically using standard alkali (NaOH) solution.
3. To determine the strength of strong acid and a week acid in a given mixture conductometrically against a standard alkali solution.
4. To determine the solubility and solubility product of a sparingly soluble salt conductometrically.
5. To determine the ionization constant of weak acid conductometrically.
6. To determine heat of solution of solid calcium chloride and calculate lattice energy of calcium chloride from its enthalpy change data using Born-Haber cycle.
7. To determine the molar volume of ethanol at room temperature in dilute aqueous solution
8. To determine the equilibrium constant of the reaction, $KI + I_2 == KI_3$ by distribution method.

(At least six experiments to be performed)

B.Sc. –III, Semester – V
CH- 501:Paper- I (Organic Chemistry)
(2019-2020)

UNIT- I **(7.5 Hrs)**

Organic compounds of Nitrogen : Preparation of nitroalkanes and nitrobenzene, chemical reactions of nitroalkanes. Mechanism of nucleophilic substitution in nitrobenzene and their reduction in acidic, neutral and alkaline media. Picric acid- preparation and uses,

Amines : Structure and nomenclature of amines, Physical properties, stereochemistry of amines, separation of mixture of 1°, 2° and 3° amines by Hoffmann's method, structural features affecting basicity of amines, preparation of alkyl &aryl amines (reduction of nitro compounds and nitriles), reductive amination of aldehydic and ketonic compounds, Gabriel phthalimide reaction, Hofmann bromamide reaction, Reactions of amines, Preparation and synthetic transformations of aryl diazonium salts.

UNIT – II - HETEROCYCLIC COMPOUNDS: **(7.5 Hrs)**

Molecular orbital picture and aromaticity of furan, thiophene, pyrrole and pyridine. Methods of synthesis of pyridine (i) from hexamethylene diamine and (ii) Picoline. Mechanism of electrophilic and nucleophilic substitution reaction of pyridine. Chemical reaction of pyridine. Structure of pyridine. Comparison of basicity of pyrrole and pyridine. Introduction to condensed five and six membered heterocycles. Preparation and reactions of Indole, Quinoline and Isoquinoline with special reference to Fischer Indole synthesis, Skraup synthesis and Bischler Napieralski synthesis.

UNIT-III **(7.5 Hrs)**

A) Quantitative Analysis : Estimation of carbon, hydrogen, nitrogen, sulphur and halogens (only principles and calculations). Calculation of Empirical and molecular formula with Numericals

B) Organometallic compounds :

Organomagnesium compound : Grignard reagent formation, chemical reactions and structure.

Organozinc compounds : Formation and chemical reactions. Organolithium compounds: Formation and chemical reactions.

UNIT-IV - SPECTROSCOPY : **(7.5 Hrs)**

A) **Electromagnetic spectrum :** Absorption spectra, Ultraviolet absorption spectroscopy, Absorption laws(Beer Lambert law), molar absorptivity, Presentation and analysis of UV spectra, Types of electronic transitions, Effect of conjugation, concept of chromophores and auxochromes, Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated dienes and enones.

B) Infrared (IR) absorption spectroscopy : Molecular vibrations, Hook's law, Selection rules, Intensity and position of IR bands, measurement of IR spectrum. Fingerprint region, characteristic absorptions of various functional groups and application of IR spectra.

CH- 502: Paper- II (Physical Chemistry)

Unit –I Electrochemistry (7.5 Hrs)

(A) Galvanic cells, irreversible & reversible cells, emf of cell & its measurement, relation between electrical energy and chemical energy, calculation of thermodynamic quantities of a cell reactions (ΔG, ΔH & ΔS & equilibrium constant)

(B) Types of reversible electrodes : metal-metal ion electrode, gas electrode, metal insoluble salt-anion electrode, redox electrodes, amalgam electrode, Nernst equation, calculation of cell emf from single electrode potential, reference electrodes, standard electrode potential, concentration cells with & without transference, liquid-junction potential, salt bridge & its functions. Applications of emf measurements in : (i) pH- determination using hydrogen electrode, quinhydrone electrode & glass electrode (ii) Potentiometric titration(Acid –Base and Redox titrations). Numericals Problems.

Unit II : Quantum Chemistry and Molecular Orbital Theory: (7.5 Hrs)

A) **Quantum Chemistry** Schrodinger wave equation for H-atom, separation in to three equations (without derivation), quantum numbers and their importance,. Hydrogen like wave functions, radial wave functions and angular wave functions. Concept of orbital, shapes of orbital. Radial probability distribution curves for 1s, 2s, 2p, 3p and 3d orbitals.

B) Molecular orbital theory : Born-Oppenheimer approximation, Criteria for forming M. O. from A. O., LCAO-MO method for H^{2+} ion, Physical pictures of bonding and antibonding wave functions. Calculation of energy from wave functions. Comparison of bonding and antibonding molecular orbitals. Introduction to M. O. theory for H_2 molecule. Introduction to Valance bond theory for H_2 molecule. Similarities and differences of valence bond and molecular orbital models.

Unit III:Photochemistry and Raman Spectroscopy (7.5 Hrs)

A) Photochemistry :

Interaction of radiation with matter, difference between thermal and photochemical reactions, Laws governing absorption of light. Laws of photochemistry. Jablonski diagram depicting various processes, quantum yield, determination of quantum yield of reactions, reasons for low and high quantum yields. Some examples of photochemical reactions (e.g. Photochemical decomposition of Hydrogen iodide, Photosynthesis of HBr from H_2 and Br_2 and photosynthesis of HCI from H_2 and Cl_2) Photosensitization, Photosensitized reactions. Numericals Problems.

B) Raman Spectroscopy :

Raman Effect, explanation of Rayleigh's lines, Stoke's lines and antistoke's lines, Experimental set up of Raman spectrometer. Pure rotational Raman spectra of diatomic molecules, rotational-vibration Raman spectra of diatomic molecules. Advantages of Raman spectroscopy over Inrfra red spectroscopy.

UNIT-IV: Colligative properties and Macromolecules (7.5 Hrs)

A) Colligative properties: Methods of expressing concentration of solutions, Raoults law, Relative lowering of vapour pressure, determination of molecular mass from relative lowering of vapour pressure. Osmosis and osmotic pressure of solution. Measurement of osmotic pressure by Barkeley and Hartley method. Determination of molecular mass from osmotic pressure. Elevation of boiling point of solvent, determination of molecular mass from elevation of boiling point. Depression of freezing point of the solvent. Determination of molecular mass from depression of freezing point. Van't Hoff factor, degree of dissociation and association of solute.

B) Macromolecules: Macromolecules, classification of polymers, molar masses of polymers: nuber average and weight average molar masses, determination of molar masses of macromolecules: viscometry, Osmometryand light scattering method. Kinetics of polymerization, addition and condensation polymerization. Electronically conducting polymers: poly(acetylene) poly(sulphyrnitride), poly(para-phenylene, poly(aniline). Numericals Problems.

CH-503: Laboratory Course

Practical I (Organic Chemistry):

Estimations i) Estimation of Glucose
ii) Estimation of Amide
iii) Estimation of Nitro group
iv) Estimation of Carboxylic group
v) Saponification of oil

Practical II (Physical Chemistry):

1. To determine the strength of given acid (HCL or CH_3COOH) potentiometrically using standard alkali solution
2. To determine the dissociation constant of weak acid potentiometrically by titrating it against alkali.
3. To titrate potentiometrically ferrous ammonium sulphate against potassium dichromate and calculate redox potential of Fe^{2+}/Fe^{3+} system.
4. To verify Beer-Lambert law using calorimeter and determine the concentration of given solution.
5. To determine molecular mass of a non-volatile solute by Rast method.
6. To determine the molecular weight of polymer by Viscometric method.

7. .To determine the specific rotation of a given optically active compound and the concentration of an unknown solution polarimetrically.

8. To study the rate of acid catalysed iodination of acetone.

(At least six experiments to be performed)

B.Sc. –III, Semester – VI

CH – 601: Paper- I (Inorganic Chemistry)

Unit- I

A) Metal ligand bonding in Transition Metal Complexes: (7.5 Hrs)

Limitations of Valence bond theory, Crystal field theory: Splitting of d-orbital in octahedral, tetrahedral and square planar complexes. Factors affecting the Magnitude of 10 Dq . Concept of Crystal field Stabilisatation Energy of octahedral and tetrahedral complexes. High spin low spin complexes on the basis of Δ o and pairing energy in octahedral complexes. (Numericals)

B) Electronic spectra of Transition Metal Complexes:

Jahn-Teller Effect, Conditions of distortion with respect to CFT configuration. Selection Rules (Laporte and Spin selection Rules). Hole Formalism Principle with respect to d^1 and d^9 ions. Electronic spectrum of $[Ti(H_2O)_6]^{3+}$ and $[Cu(H_2O)_6]^{2+}$ complex ions with respect to position of the band, intensity of the band, symmetry of the band and bandwidth.

Unit-II: (7.5 Hrs)

A) Magnetic Properties of Transition Metal Complexes:

Method of determination of Magnetic Susceptibility by Gouy's Method. Spin only formula and orbital contribution to magnetic moment. Magnetic properties of Octahedral and Tetrahedral complexes with respect to CFT. Numericals on magnetic moments.

B) Thermodynamic and Kinetic aspect of metal complexes:

Thermodynamic and Kinetic stability of metal complexes, their relation. Stepwise stability and overall stability constant and their relationship, Factors affecting the Stability of complexes. Determination of composition of Fe(III)-SSA complex by Mole Ratio and Job's Method.

Unit III: (7.5 Hrs)

A) Organometallic Chemistry

Definition, Nomenclature and Classification of Organometallic compounds. Preparation properties and application of Alkyl and Aryls of Li and Al. A brief account of metal ethylenic complexes (Structure only). Homogeneous Hydrogenation (Wilkinson's Catalyst reaction).

B) Metal carbonyls: Definition, preparation, properties. Structure and bonding in mononuclear carbonyls- $Ni(CO)_4$, $Fe(CO)_5$ and $Cr(CO)_6$ with respect to back □-bonding.

Unit –IV: (7.5 Hrs)

A) Bioinorganic Chemistry: Essential and Trace elements in biological processes, Metalloporphyrins with special reference to structure and role of Haemoglobin and Myoglobin in transport of Oxygen. Biological role of Na^+ and K^+ and Ca^{2+} metal ions. Sodium and potassium pump. Hypo and hyper calcimia. Calcium triggering and calcium pump.

B) Hard and Soft Acids and Bases: Classification of Acids and Bases as Hard and Soft. Pearson's HSAB Concept and its applications. Symbiosis, Antagonism.

CH- 602: Paper- II (Organic Chemistry)

UNIT- I : NMR Spectroscopy: (7.5 Hrs)

Nuclear Magnetic Resonance (NMR) spectroscopy. Proton Magnetic Resonance spectroscopy. Nuclear shielding and deshielding, chemical shift, Spin-spin splitting and Coupling constant. Areas of signals. Interpretation of NMR spectra of organic molecules such as ethyl bromide, ethanol,

acetaldehyde, 1,2 dibromoethane, ethyl acetate, toluene, acetophenone, acetyl acetone. Problem pertaining to the structure elucidation of simple organic molecules by NMR technique.

UNIT- II (7.5 Hrs)

A) ORGANIC SYNTHESIS VIA ENOLATES:

Acidity of α- hydrogens, Reactivity of methylene group. Malonic ester preparation and reaction- Acetoacetic ester - synthesis by Claisen condensation reactions, Keto - enol tautomerism of acetoacetic ester, Preparation of acetic acid, succinic acid, crotonic acid and heterocyclic compounds.

B) **CARBOHYDRATES:** Definition, classification and reaction of glucose. Mechanism of osazone formation. Determination of structure of glucose. Determination of ring size of monosaccharides. Epimerisation, mutarotation, conversion of glucose into fructose and vice-versa. Chain lengthening and shortening of aldoses(Wohl's degradation).Introduction to structures of maltose, sucrose, lactose, starch , cellulose, ribose and deoxyribose without involving structure determination.

UNIT-III (7.5 Hrs)

A) AMINO ACIDS, PEPTIDES, PROTEINS & NUCLEIC ACIDS:

Classification, structure and stereochemistry of amino acids. Acids base behavior, isoelectric point and electrophoresis. Structure and nomenclature of peptides and protein. Classification of proteins. Protein denaturation. Structure determination of proteins (primary and secondary).

NUCLEIC ACIDS: Introduction, constituents of nucleic acids. Ribonucleosides and Ribonucleotides. Double helical structure of DNA.

B) FATS, OILS AND DETERGENTS : Natural fats, edible and industrial oils of vegetable origin, Glycerides, hydrogenation of unsaturated oils, Definition of Saponification value, Iodine value, Acid value, Soaps, Synthetic detergents, Alkyl and aryl sulfonates.

UNIT- IV **(7.5 Hrs)**

A) SYNTHETIC DYES: Colour and constitution (Witt theory, electronic concept) Classification of Dyes based on chemical constitution. Synthesis and uses of Congo red, Crystal violet, Phenolphthalein and Alizarin dye.

B) SYNTHETIC DRUGS: Definition, Classification, Preparation, properties and uses of: Aspirin, aracetamol, Dettol, Chloroquine, Phenobarbitone, Chloramphenicol, Chloramine T.

C) SYNTHETIC POLYMERS: Addition or chain growth polymerization, free radical. Vinyl polymerization, Ionic vinyl polymerization, Ziegler - Natta polymerization .Condensation or step growth polymerization. Polyesters, polyamides,

CH-603: Laboratory Course

Practical-I (Inorganic Chemistry):

A) Gravimetric Analysis

i)Estimation of Ba^{2+} as $BaSO_4$,

ii) Estimation Ni^{2+} as Ni-DMG

B) Colorimetery

i) Colorimetric or spectrophotometric estimation of copper (II) in commercial copper sulphate sample as ammonia complex.

ii) Jobs method of determination of composition of Fe- SSA complex

iii) Mole Ratio Method of determination of composition of Fe- SSA complex

Practical-II (Organic Chemistry):

Separation of an organic mixture containing two solid components using NaOH /NaHCO3 for separation , identification of the components and preparation of suitable derivatives (minimum five mixtures)