Syllabus for Lab Assistant Exam (Chemistry) 2014

Metallic and electrolytic conductors: Conduction of electricity by metals and solutions. Classification of substances- electrolytes and nonelectrolytes. Arrhenius theory of electrolytic dissociation. Specific, equivalent and molar conductance - measurement of conductance - variation of conductance with dilution for strong and weak electrolytes, Debye-Huckel- Onsager (D-H-O) theory of electrolytic conductance. Transport number and its determination by Hittorff's and moving boundary method. Effect of temperature and concentration: ionic mobility and ionic conductance - Kohlrausch's law and its applications.

Alkanes: Introduction, Preparation of alkanes, hydrogenation of alkenes and alkynes, Reduction of alkyl halide (Metal & mineral acid, Grignard reagent) and Corey House synthesis. Reactions: combustion and halogenation, free radical mechanism (orientation, reactivity, transition state and reaction intermediates, stability and relative energy of free radicals)
Alkyl halides: Introduction, synthesis of alkyl halides from alcohols, hydrocarbons, alkenes, alkynes. Reactions: S_N1 and S_N2 reactions (concept of substrate, nucleophile, leaving group, kinetics and solvent effect). Reaction of alkyl halides with OH^-, H_2O, $RC \equiv C^-$, CN^-, NH_2, R-M, I^-, $RCOO^-$.
E_1 and E_2 mechanism of dehydrohalogenation, orientation and reactivity: Generation of carbocation, structure, stability, energy diagram, rearrangement and reactions of carbocation.

Principles of qualitative analysis.
Methodologies used in quantitative analysis.
Significant figures, Types of Errors involved during analysis- determinate and indeterminate, detection of errors and correction , rejection of data (based on standard deviation, coefficient of variation and Q- test)
Titrimetric Analysis- Neutralization, redox, complexometric and precipitation titrations
Principles of gravimetric analysis.
Applications of metal complexes in quantitative and qualitative analysis.
Flame Emission Spectroscopy- Principle, Instrumentation and Applications

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Heavy chemicals in industries, Special methodology used in the manufacture (including the physicochemical principles involved), properties and uses of sulphuric acid, nitric acid and ammonia.
Types of cement and their manufacturing processes, reactions involved in the setting of cement. Role of lime and gypsum.
Fertilizers: Definition, types, properties and classification. Nitrogeneous fertilizers, phosphate fertilizers, potassium fertilizers, NPK fertilizers, micronutrients, biodegradable fertilizers.
Marine chemicals: nodules, recovery of Br2, I2 and Mg.
Alkenes: Introduction, geometric isomerism and nomenclature, preparation of alkenes, from halides, dehydration of alcohols and dehalogenation of vicinal dihalides, Saytzeff's rule. Electrophillic addition reactions and orientation; mechanism of addition of H2, X2, HX,H2SO4, H2O and X2/H2O, addition of alkene, oxymercuration-demercuration, hydroboration, hydroxylation (syn. and anti), Structure, reactivity and stability of allyl and vinyl radicals, ozonolysis and its use in structure determination.
Alkynes: Introduction, acidity of alkynes and formation of acetylides with Na, Ag, Cu and Grignard reagents. Preparation and reaction of alkynes with H2, X2, HX and H2O. Resonance and tautomerism.
Nuclear Chemistry: Fundamental particles of nucleus, isotopes, natural abundance, stability of nucleus, n/p ratio, mass defect and nuclear binding energy, Einstein's mass energy relationship. Natural radioactivity and disintegration rate, half life, average life, artificial transmutation and radioactivity. Radioactive series. Nuclear reactions, nuclear fission, principle and types of nuclear reactors (thermonuclear and fast breeder), nuclear fusion, thermonuclear radiations, Mechanism of solar energy (proton-proton chain and Carbon/ nitrogen cycle). Applications of radioactivity in chemistry and industry.
Electronic configuration and chemical properties:
Origin of quantum numbers and their relation to the symbols and energy of atomic orbitals, radial and angular probabilities.
Electronic configuration and Periodic properties – atomic size, ionization energy, electron affinity, electronegativity. Trends in the metallic character. Ionization of elements and stabilization of various

oxidation states.
Characteristic and distinctive properties of elements.
Chemistry of s Block elements:
Hydrogen. Hydrides - Classification and Chemistry.
Alkali Metals: Li, Na, K, Rb and Cs – occurrence, comparative study of elements, oxides, halides, hydroxides and carbonates. Exceptional property of Lithium.
Alkaline Earth Metals: Be, Mg, Ca, Sr and Ba - occurrence, and comparative study of the elements, oxides, hydroxides, halides, sulphates and carbonates. Exceptional property of Beryllium.
p-Block elements: Comparative study of the elements of Groups 13-18 with special reference to electronic configuration, structure of elements and trends in atomic and ionic radii, ionization potential, electron affinity, electronegativity, metallic character and oxidation states. Inert pair effect.
Alkanes: Introduction, Preparation of alkanes, hydrogenation of alkenes and alkynes, Reduction of alkyl halide (Metal & mineral acid, Grignard reagent) and Corey House synthesis. Reactions: combustion and halogenation, free radical mechanism (orientation, reactivity, transition state and reaction intermediates, stability and relative energy of free radicals).
Alkyl halides: Introduction, synthesis of alkyl halides from alcohols, hydrocarbons, alkenes, alkynes. Reactions: SN
1 and SN
2 reactions (concept of substrate, nucleophile, leaving group, kinetics and solvent effect). Reaction of alkyl halides with OH- , H2O, RC =C-, CN- ,NH3, R-M, I-, RCOO-.
E1 and E2 mechanism of dehydrohalogenation, orientation and reactivity*:* Generation of carbocation, structure, stability, energy diagram, rearrangement and reactions of carbocation.
Principles of qualitative analysis:
Methodologies used in quantitative analysis.
Titrimetric Analysis- Neutralization, redox, complexometric and precipitation titrations,
Principles of gravimetric analysis.
Applications of metal complexes in quantitative and qualitative analysis.
Flame Emission Spectroscopy: Principle, Instrumentation and Applications.
Chromatography : Principle, Mechanism of separation: adsorption, partition & ion exchange.
Development of chromatograms: frontal, elution and displacement methods.
Qualitative and quantitative aspects of chromatographic methods of analysis: Paper Chromatography, Thin Layer Chromatography and Column chromatography.
Solvent extraction: Principle, extraction of organic species from the aqueous and non aqueous media.
Atomic Structure : Dual nature of radiation and matter, de Broglie's principle, Heisenbe rg's Uncertainty principle, Schrödinger wave equation and its interpretation, origin of quantum numbers and symbols for orbitals, shapes of orbitals - s, p, d. Radial and angular probabilities.
Electronic configuration and Periodic properties – atomic size, ionization energy, electron affinity, electronegativity. Trends in the metallic character.
Chemical Bonding: Introduction to types of bonds.
Ionic compounds: Lattice energy and factors affecting it, Madelung constants, Born-Haber Cycle. Applications of lattice energetics. Solvation energy. Effect of lattice energy and solvation on the solubility of ionic compounds.
Covalent bonding : Valence Shell Electron Pair Repulsion (VSEPR) theory and shapes of simple covalent molecules like H2O, NH3, BF3, CH4, PCI5, SF6, IF7.
Valence Bond Theory (VBT) - assumptions, linear combination of atomic orbitals and properties of hybrid orbitals. hybridization involving s, p and d orbitals (dsp2, sp3d, dsp3, d2sp3, sp3d2, sp3d3) and shapes of simple molecules like SF6, IF5, PCl5, IF7. Concept of resonance (including examples of various oxyanions).
Nuclear Chemistry: Fundamental particles of nucleus, isotopes, natural abundance, stability of nucleus, n/p ratio, mass defect and nuclear binding energy, Einstein's mass energy relationship. Natural radioactivity and disintegration rate, half life, average life, artificial transmutation and

radioactivity. Radioactive series. Nuclear reactions, nuclear fission, principle and types of nuclear reactors (thermonuclear and fast breeder), nuclear fusion, thermonuclear radiations, Mechanism of solar energy (proton-proton chain and Carbon/ nitrogen cycle). Applications of radioactivity in chemistry and industry.

Benzene: Structure, Huckel rule. Electrophillic substitution reactions with mechanism: Nitration, Sulphonation, Halogenation, Friedel-Craft's alkylation and acylation, Reactivity and orientation,

*Arenes: S*ynthesis, substitution reactions, side chain and ring halogenation and side chain oxidation. Structure and stability of benzyl cation, Alkenyl and alkynylbenzenes:Nomenclature, synthesis and reactions.

Polynuclear Aromatic Hydrocarbons: Preparation and reactions of naphthalene, anthracene, phenanthrene, naphthol and naphthyl amine.

Characteristic and distinctive properties of s, p, d and f block elements.

Chemistry of s Block elements:

Hydrogen. Hydrides - Classification and Chemistry. Heavy water – manufacture and properties.

Alkali Metals: Li, Na, K, Rb and Cs – occurrence, comparative study of elements, oxides, halides, hydroxides and carbonates. Exceptional property of Lithium.

Alkaline Earth Metals: Be, Mg, Ca, Sr and Ba - occurrence and comparative study of the elements, oxides, hydroxides, halides, sulphates and carbonates. Exceptional property of Beryllium.

p-Block elements : Comparative study of the p-Block elements- Groups 13-18 with special reference to electronic configuration, structure of elements and trends in atomic and ionic radii, ionization potential, electron affinity, electronegativity and oxidation states. Inert pair effect. Occurrence, extraction and important uses of p-Block elements.

Alcohols: Introduction. Preparation: oxymercuration-demercuration, hydroboration-oxidation, hydroxylation of alkenes, Grignard reaction, hydrolysis of alkyl halides. Reactions with HX, PX3, dehydration and oxidation. Esterification. 1,2-Glycols, glycerol, preparations and reactions, periodic acid oxidation, pinacol – pinacolone rearrangement.

Ethers: Nomenclature, preparations, reactions, cleavage, auto oxidation, Ziesel's method.

Cyclic ethers : epoxides, synthesis, acid and base catalysed opening. Orientation, reaction with Grignard and organolithium reagents. Crown ethers.

Stereochemistry: Isomerism, conformation of butane, optical activity, specific rotation, Newman and Fischer Projection, chirality, enantiomers, diastereoisomers, meso compounds .

1. Volumetric analysis:

Acidimetry – Alkalimetry

Oxidation – Reduction

Iodometry – Iodimetry

Complexometry

2. Qualitative analysis of Inorganic Salts (single salts with one cation and one anion)

3. Spotting of mono-functional Organic Compounds via elemental analysis and

Chemistry (Practicals)

1. Qualitative analysis of Inorganic Salts (single salts with one cation and one anion)

2. Spotting of mono-functional Organic Compounds via elemental analysis

and functional group analysis.

3. Volumetric analysis

a. Acidimetry – Alkalimetry

b. Oxidation – Reduction

c. Iodometry – Iodimetry

a. Complexometry

4. Viscosity

5. Surface tension

6. Chemical Kinetics

7. Organic Estimations:
a. Phenol/ Aniline
b. Amide/ ester
Molecular Orbital Theory (MOT) - Formation of bonding and antibonding molecular orbitals and bond order. Graphical representation of orbital energies (MO diagram). Bonding in homodiatomic molecules/ions like N2, F2, B2 , C2 , O2, O2
-, O2
+ with MO diagrams, relation between
bond order and bond lengths, magnetic properties. Bonding in hetero-diatomic molecules/ions like CO, NO, NO+ and HX. The concept of polarization of a bond.
Partial ionic character and Fajan's rules, Van der wall's forces, other weak electrostatic forces and H-bonding (intra and inter).
Coordination compounds: Introduction to basic terminologies (primary and secondary coordination spheres, ligands and their types, Coordination number and coordination geometry, chelation, sequestering agents), Effective Atomic Number (EAN) and 18 electron rules. Bonding in complexes with coordination number 4 & 6 in terms of VBT, high and low spin complexes. Capability and limitations of VBT.
Aldehydes and Ketones: Introduction, preparation: oxidation, reduction, Reimer–Tiemann reaction, Friedel–Crafts acylation, use of lithium dialkylcuprites. Reactivity, nucleophilic addition reactions, oxidation, reduction, Cannizzaro reaction, haloform reaction, Beckmann Rearrangement.
Carboxylic acids: Introduction, acidity, Preparation: oxidation of primary alcohols, alkylbenzene s, carbonation of Grignard reagents, hydrolysis of nitriles. Reactions of carboxylic acids: Hell-Volhard-Zelinesky reaction, reduction, conversion into acid chlorides, anhydrides, esters and amides, mechanism of esterification and decarboxylation. Preparation and reactions of dicarboxylic acids, conversion to anhydrides and imides.
Thermodynamics: Definition and explanation of terms - types of systems, intensive and extensive properties, thermodynamic process - cyclic, reversible, irreversible, isothermal and adiabatic processes.
Zeroth law of thermodynamics : concept of heat and work. Internal energy and enthalpy.
First law of thermodynamics: Statement and equation, Cp and Cv relationship - calculation of W, E and H for the expansion of ideal gases and real gas under reversible, isothermal and adiabatic conditions. Joule - Thomson effect, inversion temperature and its significance.
Thermochemistry: Standard states, standard enthalpy of formation-Hess's law of heat summation and its application. Kirchoff's equation.
Gaseous State: Recapitulations of Ideal gas/Real gas, Heat capacity (molecular basis), Heat capacity ratio. Deviation from ideal gas Behavior - Boyle temperature, Compressibility Factor. Derivation of van der Waals gas equation. Liquefaction of gases, Critical phenomenon and critical constants, Law of corresponding states, Reduced equation of s tate, Joule -Thomson effect and Inversion temperature (definition). Methods of liquefaction of gases: Faraday's, Linde's method and Claude's method.
Liquid State: Intermolecular forces and structure of liquids (qualitative description) Definition and determination of Vapour Pressure, Surface tension, Viscosity and the ir variation with temperature. Parachor and its importance.
Solid State: Recapitulations, Symmetry elements in crystals. Laws of crystallography: Law of constancy of interfacial angles, Law of rationality of indices, Law of symmetry. X-ray diffraction by crystals. Derivation of Bragg's law, Structure of few metallic elements, ionic solids (NaCl and KCl) radius ratios, defects in solids.
Colloidal State : Classification of colloids, Preparation and purification of sols, Stability of sols, Schulze-Hardy rule, Gold Number. Emulsions, gel and foam. Association colloids, Surfactants, Micelle formation and critical micelle concentration, Action of soap.

Applications.
Mesomorphic state: Difference between liquid crystal, liquid and solid. Classification and structure of nematic, smectic and cholesteric phases. Non-conventional liquid crystals. Applications.
Electrochemistry:
Metallic and electrolytic conductors: Conduction of electricity by metals and solutions. Classification of substances- electrolytes and nonelectrolytes. Arrhenius theory of electrolytic dissociation. Specific, equivalent and molar conductance - measurement of conductance - variation of conductance with dilution for strong and weak electrolytes,
Ionic Equilibria : Arrhenius theory of electrolytic dissociation, ionic product of water, pH scale, measurement of pH, common ion effect, Henderson's equation, buffer solutions, buffer capacity. Hydrolysis of salts.
Electrolytic and galvanic cells, reversible and irreversible cells. EMF of a Cell and its measurement. Nernst's equation. Determination of E0 and equilibrium constant of cell reaction. Standard electrodes (including reference electrodes). Electrochemical series of electrode potentials. Convention for half cell potential. Applications of EMF measurements.
Coordination compounds: Introduction to basic terminologies (primary and secondary coordination spheres, ligands and their types, CN, chelation), Effective Atomic Number(EAN) and 18 electron rule. Bonding in complexes with coordination number 4 & 6 in terms of VBT, high and low spin complexes. Capability and limitations of VBT.
Electrostatic concept of complex formation : Crystal field theory, (CFT), energy of d orbitals in spherical, octahedral, tetrahedral and square planar fields. Weak field and strong field complexes. Colour and magnetism of complexes on the basis of CFT.
Complexes of biomolecules and their importance.
States of matter:
Gaseous State: Ideal and Real gases, Postulates of kinetic theory of gases, derivation of Kinetic gas equation, Derivation of gas laws from kinetic gas equation, Deviation from ideal gas Behavior - Derivation of van der Waals gas equation. Liquefaction of gases, Critical phenomena.
Liquid State: Intermolecular forces and structure of liquids (qualitative description) Definition and determination of Vapour Pressure, Surface tension, Viscosity and their variation with temperature.
Colloidal State: Classification of colloids, Preparation and purification of sols, Stability of sols, Schulze-Hardy rule, Gold Number. Emulsions, gels and foams. Association colloids, Surfactants, Micelle formation and critical micelle concentration.
Mesomorphic state : Difference between liquid crystal, liquid and solid. Classification and structure of nematic, smectic and cholesteric phases.
Chemistry of Transition elements:
Characteristic properties of d-block elements. Electronic configuration. Comparative account of atomic and ionic radii, density, M.P., B.P., metallic character, reactivit y of metals, ionization energies.
Difference between the properties of the elements of first and the other two transition Series.
Application of coordination compounds in analysis and industry.
Lanthanides and Actinides : Abundance, occurrence and extraction of lanthanides and actinides.
Separation of lanthanides. Metallurgy of thorium and uranium. Preparation of transuranium elements.
Electronic configuration, oxidation states, atomic & ionic radii.
Lanthanide contraction and its consequences.
Chemistry of Transition elements:
Characteristic properties of d-block elements. Electronic configuration. Comparative account of atomic and ionic radii, density, M.P., B.P., metallic character, reactivity of metals, ionization energies.
Difference between the properties of the elements of first and the other two transition Series.
Application of coordination compounds in analysis and industry.
Lanthanides and Actinides : Abundance, occurrence and extraction of lanthanides and actinides.

Separation of lanthanides. Metallurgy of thorium and uranium. Preparation of transuranium elements. Electronic configuration, oxidation states, atomic & ionic radii.
Lanthanide contraction and its consequences.
Aryl halides: Introduction, preparation, electrophilic aromatic substitution, nucleophilic aromatic substitution, bimolecular displacement, elimination-addition (benzyne) mechanism, evidence for benzyne mechanism.
Phenols: Introduction, acidity, preparation, Reactions, ether and ester formation, nitration, nitrosation, sulphonation, halogenation, coupling with diazonium salt, Fries rearrangement, Reimer-Tiemann Reaction, Lederer-Manasse and Kolbe reactions with mechanism. Dihydric and trihydric phenols.
Ionic Equilibria : Arrhenius theory of electrolytic dissociation, ionic product of water, pH scale, measurement of pH, common ion effect, Henderson's equation, buffer solutions, buffer capacity. Multistage equilibria. Hydrolysis of salts, hydrolysis constant, degree of hydrolysis, Methods of determination of degree of hydrolysis. Relationship between Kh, Ka, Kb and Kw, Theory of Acid-Base indicators. Theory of strong electrolytes, Debye -Huckel limiting law.
Nitro compounds: Preparation of nitroalkanes and nitroarenes. Reactions: Alkylation at a-carbon, nuleophilic substitution reactions in nitroarenes, reduction of nitro compounds. Picric acid.
Amines: Structure, classification, nomenclature and physical properties of amines, preparation of alkyl and aryl amines, reduction of nitro and nitrile compounds, reductive amination of aldehydes and ketones. Hofmann rearrangement, basicity of amines, effect of substituent on basicity of aromatic amines, Hinsberg's test, quaternary ammonium salts, Hofmann exhaustive methylation, Hofmann elimination and orientation. Diazonium salts: diazotization and its mechanism, synthetic applications of aromatic diazonium salts.
Amino Acids: Introduction, Classification, Isoelectric point, Preparation: ma lonic acid synthesis, Gabrial phthalimide synthesis, Reactions.
Peptides and proteins: Structure of peptides and proteins, nomenclature of peptides classification of proteins, peptide structure determination, end group analysis, selective hydrolysis of peptides, classical peptide synthesis, solid phase peptide synthesis, protein denaturation. *Nucleic acids:* Introduction, nucleoproteins, structure of nucleic acids, ribonucleosides and ribonucleotides, the double helical structure of DNA, genetic code.
1. Volumetric analysis :
i. Oxidation - reduction
ii Iodometry
ii. Complexometry
iv. Mohr's Method
2. Qualitative analysis of Inorganic Mixtures containing 4 (four) radicals.
3. Systematic analysis of Organic compounds wit h more than one functional groups.
4. Organic Estimations:
i. Phenol/ Aniline
ii. Amide
iii. Nitro group
5. Physical Experiments:
i. Hydrolysis of methyl acetate
ii. Partition coefficient of Benzoic acid
iii. Surface tension by Stalagmometer
iv. Viscosity.
Aldehydes and Ketones : Introduction, preparation: oxidatio n, reduction, Reimer–Tiemann reaction, Friedel–Crafts acylation, use of lithium dialkylcuprates. Reactivity, nucleophilic addition reactions, oxidation, reduction, haloform reaction, aldol condensation, Claisen condensation, Wittig reaction, Beckmann Rearr angement.

Carboxylic acids and their derivatives: Introduction, acidity, Preparation: oxidation of primary alcohols, alkylbenzene s, carbonation of Grignard reagents, hydrolysis of nitriles. Reactions of carboxylic acids: Hell-Volhard-Zelinesky reaction, reduction, conversion into acid chlorides, anhydrides, esters and amides, mechanism of esterification and decarboxylation. Anhydrides and imides.
Amines: Structure, Introduction, preparation of alkyl and aryl amines, reduction of nitro and nitrile compounds, reductive amination of aldehydes and ketones. Hofmann rearrangement, basicity of amines, effect of substituent on basicity quaternary ammonium salts, Hofmann exhaustive methylation, Hofmann elimination and orientation. diazotization and its mechanism, synthetic applications of aromatic diazonium salts.
Amino Acids: Introduction, Classification, Isoelectric point, Preparation: malonic acid synthesis, Gabrial phthalimide synthesis, Reactions.Synthesis of Peptides: Classical peptide synthesis, solid phase peptide synthesis.
Thermodynamics: Definition and explanation of terms - types of systems, intensive and extensive properties, thermodynamic process - cyclic, reversible, irreversible, isothermal and adiabatic.
Zeroth law of thermodynamics: concept of heat and work. Internal energy and enthalpy.
First law of thermodynamics: Statement and equation, Cp and Cv relationship - calculation of W, E and H for the expansion of ideal gases and real gas under reversible, isothermal and adiabatic conditions. Joule - Thomson effect, inversion temperature and its significance.
Thermochemistry: Standard states, standard enthalpy of formation-Hess's law of heat summation and its application.
Second law of thermodynamics and its significance, Gibbs free energy.
Preparation of high purity silicon, silicon based semiconductors and devices.
Silicones. Synthesis and structure of silicone fluids, greases, resins and rubbers. Thermal stability, water and chemical resistance. Applications in various fields like medicine to electronics and construction.
Glassy state. Manufacturing of glass, structure of glass, colouring and decolorization in glass making, change in physical properties of glass with variation in additives. Various types of glass and their use.
Ceramics: General properties, classifications, raw materials and formation of clay, types and typical properties of clays, manufacturing process of potteries, application of colours to pottery, use of ceramics in resistors and capacitors.
Refractories: Properties, classification, manufacture of fire clay bricks, silica bricks, pure oxides, super refractories and insulating refractories.
Schrodinger wave equation, Laplacian operator, Energy associated with particle in one dimensional box (qualitative treatment).
Polar coordinates r, q and f. Separation of the wave equation in translational and rotationalparts, F, Q and R equations and the F(f), Q(q) and R(r) functions. Quantum numbers derived from the wave equation, relation between quantum numbers and radial and angular nodes, spherical harmonics and shapes of orbitals.
Radial probability, Screening effect and order of suborbital energies in multielectronic atoms, Ground spectral states of atoms and ions (up to Z=30).
Elementary concept of symmetry elements and symmetry operations, Point symmetries, CnV, D4h, D6h, Td and Oh.
Introduction to Spectroscopy: Electromagnetic spectrum, interaction of electromagnetic radiation with matter, atomic and molecular spectroscopy, absorption and emission spectroscopy.
Ultraviolet-Visible (UV-Vis) Spectroscopy: Absorption laws, instrumentation, UV-Vis spectrum, types of electronic transitions, concept of chromophore and auxochrome, UV spectra of alkenes, conjugated enes, enones and aromatic compounds.
Infrared (IR) Spectroscopy: Molecular vibrations, Hooke's law, selection rules, instrumentation and meas urement of IR spectrum, Fundamental, overtone, combination and coupled bands, fingerprint region, characteristic absorptions of various functional groups.
Phase equilibria I : Phases, components, degrees of freedom, equilibrium between phases, phase

boundaries, phase stability and phase transitions, Ehrenfest classification of phase transitions, phase diagrams. Derivation of phase rule and Experimental procedures for phase studies. One component systems (Water, sulphur, carbon dioxide, carbon, helium), supercritical fluid. Two component systems involving eutectics, congruent and incongruent melting points. Solid solutions, partial miscibility in solid and liquid states. Fractional crystallization, Ultrapurity and controlled impurity, zone refining.

Chemistry of Boron family : Electron deficiency and acceptor behavior, Oxides, hydroxides and halides, boronnitride and borazole. Structure, bonding and important applications.
Boranes, borohydrides and carboranes.

Chemistry of Carbon family: Allotropy, trends in metallic properties and conduction, structure, bonding and properties of oxides. Carbides, graphitic compounds, silicates, zeolites, feldspars, ultramarines and clay minerals. Synthetic zeolites and clays.

Nitrogen family: hydrazine, hydroxylamine and hydrazoic acid, hydrides of other elements, Oxides and halides, Oxyacids of nitrogen and phosphorous.

Chemistry of Oxygen family : Ozone, oxides, peroxides and superoxides. Oxyacids and halides of sulphur, peracids and persalts of sulphur, Chemistry and applications of lead compounds, toxicity and bio logical role of selenium and tellurium.

Chemistry of Halogens: Oxides and oxyacids of halogens, peracids and persalts, interhalogen compounds, pseudohalogens and polyhalides, basic properties of Iodine,
Chemistry of Astatine.

Chemistry of Noble Gases: Oxides, fluorides and oxyfluorides of xenon.

Preparation of high purity silicon, silicon based semiconductors and devices.

Silicones. Synthesis and structure of silicone fluids, greases, resins and rubbers. Thermal stability, water and chemical resistance. Applications in various fields like medicine to electronics and construction.

*Glass*y state. Manufacturing of glass, structure of glass, network formers and networkmodifiers, colouring and decolorization in glass making, change in physical properties of glass with variation in additives. Various types of glass and their use.

Ceramics: General properties, classifications, raw materials and formation of clay, types and typical properties of clays, manufacturing process of potteries, application of colours to pottery, use of ceramics in resistors and capacitors.

Refractories: Properties, classification, manufacture of fire clay bricks, silica bricks, pure oxides, super refractories and insulating refractories.

Conformation and Chirality: Conformation, stability of conformers, conformation of cyclohexane, mono- and di-substituted cyclohexanes, conformation of glucose.
Chiral molecules: generation of chiral centre, reactions remote from chiral centre, application in correlation of chiral compounds, generation of another chiral centre, reaction with chiral compounds, resolution, stereochemistry of addition of halogens to alkenes. Chirality in biphenyls, allenes and spiro compounds.

Carbohydrates: Classification and nomenclature, open chain and cyclic structure of glucose, determination of ring size, mutarotation and its mechanism, epimers, chain shortening and chain lengthening of aldose, conversion of glucose to fructose and Mannose, conversion of fructose to glucose, formation of glycosides, ethers and esters, erythro and threo diastereoisomers.
Disaccharides and polysaccharides: Introduction to maltose, sucrose and lactose, starch and cellulose.

Energy production in biological systems, biological oxidation of alcohols and carbohydrates.

Heterocyclic compounds: Introduction, structure, molecular orbitals and aromaticity in pyrrole, furan and thiophene, mechanism of electrophilic and nucleophilic substitution reactions; basicity of pyridine, piperidine and pyrrole.

Condensed five and six member heterocycles : preparation and reactions of indole, quinoline and isoquinoline, Fischer indole synthesis, Skraup synthesis, Bischler-Napieralski synthesis,

electrophilic and nucleophilic substitution reactions of indole, quinoline and isoquinoline.
Electrochemistry I: Electrolytic and galvanic cells, reversible and irreversible cells. EMF of a Cell and its measurement. Nernst's equation. Determination of E0 and equilibrium constant of cell reaction. Standard electrodes (including reference electrodes). Electrochemical series of electrode potentials. Convention for half cell potential. Applications of EMF measurements: Determination of solubility product, pH, mean activity coefficient, transport number. Potentiometric titrations : Acid-base, Precipitation and Redox. Weston-Cadmium cell
Second law of thermodynamics : Need for the II law, statements of the second law. Spontaneous process, Carnot's cycle and efficiency of heat engine. Concept of entropy, definition, entropy of an ideal gas, entropy changes in cyclic, reversible and irreversible processes and physical transformations. Calculation of entropy changes with changes in T, V and P, entropy of mixing.
Gibbs free energy, Helmholtz work functions, their variations with temperature, pressure and volume. Criteria for spontaneity, Gibbs-Helmholtz equations- derivation and its applications.
Third la w of Thermodynamics: Nernst heat theorem statement of Third law of thermodynamics. Evaluation and absolute entropy from heat capacity measurements.
Exception to Third law.
Chemical Equilibrium: Equilibrium constant and free energy, Thermodynamic derivation of law of mass action, Le Chatelier's principle. Reaction isotherm and isochore-Clapeyron equation and Clausius-Clapeyron equation, applications.
Partial Molar Properties : Chemical potential, Gibbs Duhem equation- effect of temperature and pressure on chemical potential, chemical potential in system of ideal gases, Duhem-Margules equation. Concept of Fugacity, activity and activity coefficient, Methods for determination of fugacity of gas.
Metallic Properties: Properties of metals, crystal structure of metals, electron gas theory and Pauling's theory of metals, Band theory, Alloys, Hume-Rothery rules.
Simple idea of conduction, Semiconductors and insulators. Magnetic and electrical properties of solids. Introduction to superconductivity.
Molecular orbital (MO) theory of multiatomic molecules and ions : linear triatomic molecules like BeCl2 and CO2, planar AB3 type molecules like BCl3 and CO3
2-, tetrahedral molecules
like CH4, NH4
+, and SO 4
2-. Comparison with valence bond theory.
Coordination compounds : Covalent interaction in metalcomplexes and hybridization involving d-orbitals, high and low spin complexes. Limitations of VBT.
Electrostatic concept of complex formation : Crystal field theory, (CFT), energy of d orbitals in spherical, octahedral, tetrahedral, tetragonal and square planar fields. Extrinsic and intrinsic distortion in octahedral geometry, Weak field and strong field complexes.
Spectrochemical series, colour, magnetism and geometry of complexes on the basis of CFT. Factors affecting the crystal field splitting. Geometry preferred by various transition metal ions in strong and weak fields. Limitations of crystal field theory (qualitative approach).
Isomerism in complexes.
Stability of complexes formed by transition metal ions and the factors influencing it.
MàL andLàM p interaction in metal complexes.
Introduction to organometallic compounds, Metal carbon s-bonds, s -bonding in metalcarbonyls and nitrosyls.
Mechanism of inorganic reactions: Hard and soft acids and bases, classification of acceptors and donors, the concept of acceptor A and B. Metal and ligand substitution reactions.
Complementary and non-complementary redox processes, atom transfer and electron transfer mechanisms.

Metal complexes in biology and medicine.
Mass Spectrometry: Instrumentation, fragmentation of simple organic molecules.
Nuclear Magnetic Resonance (NMR) Spectroscopy: Nuclear magnetic resonance, instrumentation, proton NMR, nuclear shielding and deshielding, chemical shift, spin-spin splitting, interpretation of NMR spectra of simple organic molecules.
Interpretation of UV, IR and NMR spectra, problems based on combined use of spectral data.
Macromolecules: Importance of polymers. Basic concepts: Monomers, repeat units, degree of polymerization. Linear, branched and network polymers, classification of polymers. Chain growth (free radical, ionic and coordination) and step growth polymerization and copolymerization. Polydispersion-average molecular weight concept, Number, weight and viscosity average molecular weights, The practical significance of molecular weight, Molecular weight determination using viscosity method, Osmometry, Cryoscopy,
Ebullioscopy (qualitative description) Polymer degradation and environmental concerns.
Comparative studies of Group 3 to 12, occurrence and extraction of elements, Ionic salts, Stoichiometric and non-stoichimetric oxides, trends in the acidic/ basic characteristic of oxides and hydroxides. Horizontal comparison in iron, cobalt and nickel groups.
Iso and heteropolyacids and their salts.
Tungsten bronzes.
Complex formation by transition metal ions in different oxidation states, colour, magnetic properties and catalytic properties.
Structure and uses of representative compounds of various transition elements.
Chemistry of platinum group elements, application of platinum group metals and their compounds in catalysis.
Redox potentials and electrochemical series, analysis of redox cycle, redox stability in water, Disproportionation, oxidation by atmospheric oxygen, presentation and use of redox potential data- Frost, Latimer and Pourbaix diagrams, pH dependence of redox and conditional Latimer diagrams, trends in stabilities of the oxidation states of metals.
Effect of complex formation on redox potentials and stabilization of oxidation states of transition metal ions in various complexes.
Inorganic complexes and compounds in catalysis: Ziegler-Natta catalyst, Hydrogenation of alkenes, Wacker process, Water gas shift reaction (oxo process).
Chemistry of lanthanide and actinide compounds, higher coordination number and complex formation, colour and absorption spectra, magnetic properties and their important applications.
Genesis of elements and extension of periodic table.
Szilard-Chalmers' separation process, separation of Neptunium and Plutonium from 92U238 , processing of spent fuel, extraction of U233 and Pu239
Application of radioactive elements and radioisotopes in agriculture, industries and clinical diagnosis. Preliminary concept of damage to DNA from nuclear radiations.
Metallurgy of Titanium, Zirconium, silver and gold. Powder metallurgy of Platinum.
Inorganic colours: pigment types, physical and chemical properties, choice of pigment, synthetic iron oxide, titania, colloidal gold, zircon, glaze stains.
Chemistry of Natural Products: Terpenes: Classification and isolation, structure and synthesis of citral, geraniol and a-terpeniol, essential oils.
Alkaloids: Classification, isolation, physiological activity, and general characteristics, structure elucidation and synthesis of nicotine, coniine and papaverine.
Fats: Occurrence and composition of fats, saponification, gener al chemical properties of fats, hydrolysis, hardening of oil, rancidity, phosphoglycerides.
Drugs: Classification, methods of preparation and uses of Aspirin, mode of action, salol principle, true and partial salol, sulphanilamide, sulphathiazole, succinoyl sulphathiazole, mechanism of action of sulpha drugs.
Synthetic Dyes: Introduction, classification of dyes, colour and constitution, methods of

preparation and uses of methyl orange, congo red, malachite green, crystal violet, phenolphthalein and fluorescein.
Pericyclic Reactions: Molecular orbitals of ethyle ne and 1,3-butadiene, and 1,3,5- hexatriene, Photochemical and thermal reactions, [2+2] and [4+2] cycloaddition reactions, the Diels-Alder reaction, electrocyclic reactions, Claisen rearrangement as a sigmatropic reaction, Photochemical reactions: Norrish type -I and type II reactions of carbonyl compounds.
Enolates in organic synthesis: Acidity of a-hydrogen, halogenation of ketones, aldol condensation, Claisen condensation, Wittig reaction, alkylation of diethyl malonate and ethyl acetoacetate and its application in organic synthesis.
Electrochemistry II: Chemical and concentration cells with and without transference. Effect of temperature on cell voltage. Electrode polarization and overvoltage. Polarography and its applications. Amperometry and coulometry. Cyclic voltametry.
Corrosion: Definition, types, theories and mechanism for dry and wet corrosion, special types of corrosion. Chemical passivators and passivations. corrosion inhibitors.
Fuel cells: Principle, types and their functioning.
Phase equilibria II: Liquid - gas and liquid - liquid systems, Ideal/non-ideal liquids, Raoult's Law, Henry's Law, Fractional distillation of binary miscible liquids. Column efficiency, Azeotropes, Breaking of azeotropism, Lever rule, partial miscibility of liquids, lower and upper critical solution temperature, Immiscible liquid pairs, steam distillation.
Three component systems, triangular plots: Partially miscible three liquid systems. (Formation of one, two and three immiscible pairs).
Colligative properties of dilute solution : Definition, types and importance of colligative property, van't Hoff factor.
Photochemistry : Photophysical and photochemical processes, Grothus -Draper law, Stark-Einstein's law of photochemical equivalence and quantum yie ld. Electronic excitation of molecules, Frank-Condon principle. Examples of low and high quantum yields. Photostationary equilibrium. Photosensetization, Photochemical formation of HCl, HBr and HI and rate of photochemical reactions. Actinometry. Luminescence phenomenon: Timescales of photophysical processes, phosphorescence, fluorescence, chemluminescence. Quenching of fluorescence, Stern-Volmer equation. Photochemistry of stratospheric ozone, harvesting of light during plant photosynthesis, photochemistry of vision. Solar energy conversion.
Chemical Kinetics I : Rates of chemical reactions, Rate laws, Order of reaction and Molecularity, factors affecting rate of reaction. Derivation of rate constants for zero, first and second order reactions. Methods of determination of order of chemical reactions. Arrhenius equation.
Catalysis I : Catalyst, inhibitor, autocatalysis. Catalytic activity, selectivity and stability. Homogeneous and heterogeneous catalysis, General characteristics of catalytic reactions. Theories of catalysis (Chemical theory and adsorption theory). Active sites. Applications of catalysts in industries.
Adsorption : Physisorption and Chemisorption and factors affecting adsorption, Freundlich and Langmuir Adsorption Isotherms. BET isotherm (No derivation). Applications.
Chemical Kinetics II: Elementary and complex reactions, Examples of parallel, opposing and consecutive reactions, rate determining step, steady state approximation. Derivation of rate laws of complex reactions (only first order). Arrhenius equation and concept of energy of activation. Collision theory and transition state theory (elementary treatment of reaction rates). Mechanism of unimolecular reactions. Fast reactions.
Catalysis II: Role of active sites in catalysis. Turn over number. Characterization of catalysts, Acid - base catalysis. Solid acid catalysts, Importance of selectivity, Enzyme catalysis. Catalysis in atmospheric pollution control. Applications of catalysts in industries.
Solvent Extraction : batch, continuous and counter current methods of solvent extraction, Solvent Extraction systems for inorganic species, effect of pH on such systems, important analytical and industrial applications.

Chromatography: Introduction, classification, principle of separation, terminology (stationary and mobile phases, retention time, retention volume, resolution, number of theoretical plates (N) and HETP).
Paper and thin layer chromatography- choice of adsorbent and solvent , factors affecting Rf values , development techniques, important applications.
Ion Exchange Chromatography- Principle, Choice of Resins and Applications
Liquid Chromatography and HPLC-Principle, Instrumentation and Applications
GC: Principle, instrumentation and applications.
Segments of the atmosphere, Air Pollutants and their effects- Green House Effect Ozone Depletion, Photochemical smog, Acid Rain and other effects, Air Sampling and Analysis of Sulphur dioxide, oxides of nitrogen, Suspended particulate matter, Respirable particulate matter, ozone, carbon monoxide, hydrocarbons and volatile organic compounds(BTX)
Water pollutants and their general effects. General methods of treatment of waste water, Techniques for measuring water pollution, Analysis of water pollutants
1. Potentiometeric titration : strong acid – strong base
weak acid -- strong base
2. Conductomertic titration: strong acid – strong base
weak acid -- strong base
weak acid -- weak base
3. Determination of Surface tension and Parachor of liquid.
4. Determination of composition of mixture of liquids by Viscometry.
5. Determination of composition of mixture of liquids by Refractometry.
6. Molecular weight by Victor Meyer's method.
7. Adsorption of oxalic acid on charcoal.
8. Determination of percentage of glucose/sucrose by polarimetry.
9. Dissociation constant of weak acid/base by pH metry.
10. Dissociation constant of weak acid/base by Conductometry.
11. Phase diagram of a two component solid-liquid system.
12. Kinetics of inversion of cane sugar by Polarimetry.
13. Kinetics of catalytic decomposition of H_2O_2.
14. Verification of Onsager equation for strong electrolyte by conductometry.
15. Kinetics of reaction between $K_2S_2O_8$ and KI
16. Kinetics of reaction between $KBrO_3$ and KI.
17. Kinetics of hydrolysis of methyl acetate by NaOH.
18. Kinetics of reaction between $KMnO_4$ and Oxalic acid.
19. Paper / Thin Layer Chromatography
(1) Introduction to Gravimetric method of analysis and estimation of iron/ aluminium as oxide.
(2) Separation of Binary mixtures of metal ions and their estimation by suitable combination of the following methods:
a. Gravimetric analysis
b. Alkalimetry
c. Redox titrations
d. Complexometric titrations
e. Argentimetry
The following ions will be quantitatively analysed:
Cations of : Ag(e), Al(a), Ba(a). Ca(a,b), Cr(c), Cu(c,d), Fe(a,c), Mg(a,d), Mn(c,d), Ni(a,d), Zn(a,d).
Anions : Cl^-(e), $C_2O_4^{2-}$(a,b), NO_2^-(c), SO_4^{2-}(a) and $S_2O_3^{2-}$(c).
Note: The letters in parenthesis indicate the method of analysis.
Introduction to and practice of semi- micro qualitative analysis and spot reactions with

simple mixtures of ions.
Qualitative analysis of mixtures containing maximum six radicals including an ion of a rare element:
(a) Cations of: Ag, Pb, Hg, Cu, Cd, Sn, Bi, As, Sb, Fe, Al, Cr, Co, Ni, Mn, Zn, Ca, Sr, Ba, Mg, Na and K. NH_4^+.
(b) Cations of rare elements: W, Mo, Ce, Ti, Th, Zr, U, V and Li.
(c) Anions : Cl^-, Br^-, I^-, NO_2^-, NO_3^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, CrO_4^{2-}, $Cr_2O_7^{2-}$, CO_3^{2-}, PO_4^{3-}.
3. Inorganic Preparations:
Synthesis and estimation of purity of fine chemicals (Any five).
4. Analysis of alloys:
Analysis of brass and stainless steel.
Organic Chemistry :
1. Organic separation and identification of binary mixtures.: (acid/phenol/base/neutral)
i) Solid + Solid (6-7 mixtures).
ii) Liquid + Liquid (6-7 mixtures).
iii) Solid + Liquid (2-3 mixtures).
2. Organic Estimation:
i) Estimation of Aniline/ Phenol
ii) Estimation of Amide
iii) Estimation of Glucose
iv) Estimation of Ester
3. Organic Preparation (One stage preparation): (atleast five)
i) 7-Hydroxy-4-methyl coumarin from resorcinol
ii) p-Bromo acetanilide from acetanilide
iii) Acetyl salicylic acid from salicylic acid (Aspirin)
iv) Cinnamic acid from benzaldehyde
v) 1,4-Diacetoxy benzene from hydroquinone
vi) m-Nitroaniline from m -dinitrobenzene
vii) 1-Phenylazonaphthol from ß-naphthol