Tribhuvan University

Institute of Science and Technology

Three year B.Sc. Chemistry course of study

(2052)

Course Title: Basic Chemistry I **Full Marks:** 100
Course No.: CHEM 311 (major/minor) **Pass Marks:** 35
Nature of the course: Theory **Year:** I

Course Objectives:

The outcome of this course will be:

- to stimulate, create and sustain their interest in the study of chemistry.
- to provide a body of chemical knowledge appropriate for higher studies.
- to make aware the importance of scientific method of accurate experimental work.

Group A: Inorganic Chemistry

Atomic structure: Bohr's theory and refinements, wave mechanical model of the atom, matter, waves, de Broglie's equation, Heisenberg's uncertainty principle, Schroedinger's wave equation (time independent), physical significance of wave function, probability density pattern for hydrogen atom, radial and angular wave functions, radial distribution curves, shapes of s,p,d, orbitals; quantum number and their significance, energy level diagram. **10 hrs.**

Multi-electron system: Paul exclusion principle, Hund's rule of maximum multiplicity, aufbau principle and its limitations, energy level diagrams, stability of completely filled, half filled and empty orbitals.

3 hrs.

Nuclear Chemistry: Composition of nucleus (nuclear stability), binding energy, radioactivity, half life determination and nuclear reactions. **4 hrs.**

Periodic classification of elements and physical properties: Periodicity ŝ,p̂,d and f block elements, long form of periodic table, discussion of properties like atomic, ionic and covalent radii, ionization potential, screening of shielding effect, electronegativity, electron affinity. **7 hrs.**

Chemical bonding: Ionic bond: packing of ions in crystal, radius ratio, lattice energy, Born equation, Born-Haber cycle, covalent character in ionic compounds, polarizing power and polarizability (Fajan's rule), bond moment and dipole moments, percentage ionic character from dipole moments and electronegativity differences, characteristics of ionic compounds, structure of ionic solids, ionic compounds of type AX (NaClCsCl, ZnS), AX_2 (CaF_2, TiO_2), layer structures, stoichiometric and non-stoichiometric defects. **8 hrs.**

Covalent Bond: General characteristics of coordinate-covalent bond, valence bond approach, directional characteristics of covalent bond, resonance energy hybridization, multiple bounding, three electron bound, two electron three centered bond, sigma – and pi – bonds, bond length and bond order, bond strength, valence shell electron pair repulsion theory (VSEPR), theory of directed valence, shapes of simple inorganic molecules and ions containing bonds and lone pairs, hydrogen bond 9theories of hydrogen bonding, valence bond treatment), metallic bond elementary idea of L.C.A.O. and concept of united atoms in molecular orbital theory, bonding, antibonding, and non-bonding orbitals, M.O. configurations of simple diatomic molecules (H_2, He_2, N_2, O_2, F_2, CO, NO, HCI and related species). **12 hrs.**

Acids and Bases: Lewis acid – base concept, hard and soft acids and bases (HSAB), application of HSAB principle, relative strengths of acids and bases and the effect of substituents and solvents on them. 4 hrs.

Principles of qualitavive and quantitative Analysis: Solubility product, common ion effect, their application in group separation, principles of gravimetric and volumetric analysis.**9 hrs.**

Group B: Organic Chemistry

Alkane: Energetics of reaction, energy profile diagram exothermic and endothermic reactions, free rotation about the carbon – carbon single bond, conformations of n-butane, physical properties, industrial source, industrial source vs laboratory preparation, the Grignard reagent, coupling of alkyl halides with organometallic compounds, reactions halogenation, mechanism of halogenation, orientation of halogenation, relative reactivity of alkanes towards halogenation, case of abstraction of hydrogen atom, stability of free, radicals, ease of formation of free radicals, reactivity and selectivity, combustion, the green house effect, pyrolysis.**10 hrs.**

Stereochemistry: Stereochemistry and stereoisomerism, optical activity, the polarimeter, specific rotation, enantiomerism and tetrahedral carbon, enantiomerism and optical activity, prediction of enantiomerism (chi rality) the chiral center, enantiomers, the recemic, modification, configuration, specification of configurations (R and S), sequence rules, diasteomers. **7 hrs.**

Alkyl halide (Nucleophilic substitution): Homolytic and heterolytic fission, structure, classification and nomenclature of alkyl halides, physical properties, preparation, nucleophilic aliphatic substitution reactions, nucleophiles and leaving

groups, rate of reaction, the SN^2 reaction (mechanism and kinetics), the SN^2 reaction (stereochemistry, reactivity), the SN^1, reaction (mechanism and kinetics) carbocations (structure and relative stability), SN^1 reaction (stereochemistry). **8 hrs.**

Alcohols and Ethers: Introduction, structure physical properties, industrial source, fermentation, Fule from carbohydrates ethanol: preparation, reactions, alcohols as acids and bases, reaction of alcohols with hydrogen halides, formation of alkyl sulphonates, oxidation of alcohols, industrial source of ethers, preparation of ethers, Williamson synthesis, reactions of ethers. **8 hrs.**

Alkenes: Structure of ethylene, hybridization and orbital size, geometrical isomerism. Physical properties, industrial source, preparation, dehydrohalogenation of alkyl halide, kinetics of dehydrohalogenation, the E2 mechanism, the E2 mechanism (orientation and reactivity), the E1 mechanism, E1 mechanism (orientation), dehydration of alcohols, reactions of alkenes, reaction at the carbon-carbon double bond, hydrogenation, addition of hydrogen halides, addition of hydrogen bromide (peroxide effect), addition of sulphuric acid, addition of water, electrophilic addition (mechanism), electrophilic addition (orentation and reactivity), addition of halogens, mechanism of addition of halogens, halohydrin formation, oxymercuration-demercuration. Hydroboration- oxidation, orientation and mechanism of hydroboration, free radical addition (mechanism), orientation of free radical addition, hydroxylation, ozonolysis, analysis of alkenes.

Alkynes: Structure of acetylene, physical properties, industrial source of acetylene, preparation of alkynes, reactions of alkynes, reduction to alkenes, electrophilic addition to alkynes, hydration of alkynes, acidity of alkynes, reaction of metal acetylides, formation of carbon-carbon bonds. **4 hrs.**

Group C: Physical Chemistry

Gasseous State: Postulates of kinetic molecular theory and their significance, cause of gas pressure, derivation of kinetic gas equation for ideal gas, derivation of gas laws from kinetic equation, distribution of velocity of gas molecules: Maxwell's distribution of velocities of gas molecules (no derivation), average velocity, most probable velocity, root men square velocity, calculation of root mean square velocity from Maxwell's equation, relationship between different types of velocities, concept of collision number, collision frequency, collision diameter and mean free path, deviation of real gas from ideal behavior, Van der Waals equation of state, virial equation of state., Liquefaction of gas: critical state and critical constants, Van der waals constant a and b, liquefaction of gas. **12 hrs.**

Liquid State: Qualitative treatment of liquids, vapour pressure, vapour pressure and boiling point, surface tension and its determination using stalagmometer, viscosity and its determination by Ostwald viscometcr method and applications of surface tension and viscosity measurements. **3 hrs.**

Solid State: Crystalline and amorphous solids, classification of solids on the basis of dominant type of bond. **2 hrs.**

Chemical Equilibrium: Reversible reaction, the law of mass action. Relation between Kp and Kc, applications of law of mass action to homogeneous equilibrium, effect of temperature, pressure and components of chemical equilibrium, Le Chatelier's principle and its applications. **3 hrs.**

Ionic Equilibrium: Strong and weak electrolytes, Ostwald's dilution law and limitations, autoionization of water, pH and pH scale, dissociation equilibria of weak electrolytes, multistep ionic equilibria (ionization of polyprotic acids), hydrolysis and

hydrolysis constant, solubility and solubility product principle common ion effects in ionic equilibrium, buffer solution, buffer capacity and buffer range, pH change in acid base titration (weak and strong), theory of acid base indicator. **8 hrs.**

Colligative properties: Dilite solution, Raoult's law and determination of vapor pressure lowering, laws of elevation of boiling point and depression of freezing point, determination of molecular weight, osmotic pressure, laws of osmotic pressure, determination of osmotic pressure, determination of molecular weight from osmotic pressure, vant Hoff factor, abnormalities in solution due to association and dissociation. **8 hrs.**

Colloidal Solution: Colloidal state of matter, lyophilic and lyophobic colloids, preparation and purification of colloids, brief discussion of kinetic, potical and electrical properties of colloids. **4 hrs.**

Thermodynamics & Thermochemistry: Some thermodynamic terms, first law of thermodynamics, isothermal but not reversible expansion of an ideal gas isothermal reversible expansion of an ideal gas, experimental determination of ΔE using bomb calorimeter, enthalpy, experimental deterimantion of ΔH enthalpy of physical changes (enthalpy of fusion, vaporization, sublimation), enthalpy of chemical changes (enthalpy of formation, combustion, solution, dilution and neutralization), Hess's law of constant heat summation, enthalpy change from bond energy, variation of heat of reaction with temperature (Kirchoffs equation), calorific value of fuel, calorific value of food. **10 hrs.**

Course Title: Basic Practical Chemistry **Full Marks:** 50
Course No.: CHEM 312 (major/minor) **Pass Marks:** 20
Nature of the course: Practical **Year:** I

Course Objectives:
The outcome of this course will be:

- to make students aware of the importance to scientific method of accurate experimental work.
- to develop in students abilities to perform experiments having due regard for safety.
- to develop in students skills of observation and their ability to record and interpret those observations.

Volumetric analysis: Volumetric analysis involving acidimetry and alkalimetry (combination of strong and weak acids and bases), permanganate titration (estimation of iron in Mohr's salt, determination of calcium in calcium carbonate), silver nitrate titration, iodometric titration (potassium dichromate and copper sulphate). 18 hrs

Qualitative analysis of simple inorganic salt mixture containing 2 cations and 2 anions:- Hg^{+}, Pb^{++}, Ag^{+}, Cu^{++}, Hg^{++}, As^{+++}, Sb^{+++}, Sn^{++}, Bi^{+++}, Cd^{++}, Al^{+++}, Zn^{++}, Mn^{++}, Fe^{+++}, Co^{++}, Ni^{++}, Cr^{++}, Ca^{++}, Ba^{++}, Sr^{++}, Mg^{++}, K^{+}, NH_4^{+}, NO_3^{-} Cl^{-}, Br^{-}, I^{-}, SO_4^{--}, CO_3^{--}, PO_4^{---} **30 hrs.**

Purification of organic compounds: Purification of crude organic compound- recrystallization (acctanilide, benzoic acid)., Determination of purity of organic compound- melting point/mixed melting point (urea, cinnamic acid)., Determination of boiling point of an organic compound (aniline, nitrobenzene etc)., Experiment on steam distillation (isolation of limonene from orange peels)., Identification of functional groups (-COOH, -CHO, -CO, -OH, $-NH_2$ –phenol).

Determination of physical properties: Determination of surface tension of a liquid using Stalagmomenter., Determination of viscosity using Ostwald viscometer., Perparation of buffer solution from sodium acetate and acetic acid, ammonium chloride and ammonium hydroxide, measurement of pH by pH paper, universal indicator., Preparation of starch sol and to study the dialysis of starch sol containing sodium chloride through a cellophane or parchment paper., Comparison of the precipitation values of sodium chloride, barium chloride and aluminium chloride for arsenic sulphide sol., Determination of molecular weight of organic compound like acetanilide, napthalene by Rast's camphor method. **51 hrs.**

Course Title: Basic Chemistry II **Full Marks:** 100
Course No.: CHEM 321 (major/minor) **Pass Marks:** 35
Nature of the course: Theory **Year:** II

Course Objectives:
The outcome of this course will be:

- to explain their knowledge in terms of the relevant principles, concepts, theories, definition, patterns and generalization.
- to explain every day applications and uses of chemistry.
- to present chemical ideas in a clear and logical form.

Group A: Inorganic Chemistry

Refining and purification of metals: Chromatography, ion exchange, solvent extraction, oxidative fefining, parting process, zone refining, Mond's process. **5 hrs.**

Comparative study of s- and p- block elements and their important compounds: General group trends, electron configuration, atomic radii, ionization potential, electron affinity, electronegativity, inert pair effect. **20 hrs.**

Chemistry of d- block elements and their compounds: General trends in electronic configurations, ionic and covalent atomic radii, electronegativity, electron affinity, ionization potential. Colour and magnetic properties, variable valency, complex formation with reference to 3 d block elements, concepts of co-ordination complexes, Werner's theory of co-ordination compounds, comparative study of chemistry of elements of 3d-series (excluding Sc, Ti, V), chemistry of representative compound of 3d – block elements. **14 hrs.**

Preparation, properties, bonding and structure of the following: Oxides and oxyacids of phosphorous, hydrazine,

hydroxylamine, hydrazoic acid, hydrogen peroxide, ozone, sodium thiosulphate, peracids of sulphur, potassium permanganate, potassium dichromate. **12 hrs.**

Group B: Organic Chemistry

Cyclic Aliphatic Compounds: Open chain and cyclic compounds, nomenclature, industrial source, preparation, reactions, reactions of small-ring compounds, Baeyer strain theory, stabilities of cycloalkanes, orbital picture, angle strain, factors affecting stability of conformations, conformation of cycloakanes, equatorial and axial bonds. **6 hrs.**

Aromaticity: Aliphatic and aromatic compounds, structure of benzene, Kekule structure, stability of benzene ring (reactions and heats of hydrogenation and combustion), carbon-carbon bond lengths in benzene, resonance structure of benzene, orbital picture of benzene, representation of the benzene ring, Huckel's (4n+2_ rule, nomenclature of benzene derivatives, electrophilic aromatic substitution, effect of substituent groups, determination of orientation, determination of relative reactivity, classification of substituent gropus, orientation in disubstituted benzenes, mechanism of nitration, sulphonation, halogenation and Friedel-Craft reactions, reactivities and orientation, theory of orientation, electron release via resonance, effect of halogenation on electrophilic aromatic substitution. **10 hrs.**

Aldehydes and Ketones: Structure, physical properties, perparation, preparation of ketones by Friedel-Craft achylation, preparation of ketones by use of organocopper compounds, nucleophilic addition, reactions of aldehydes and ketones, oxidation, reduction, addition of cyanide, addition of derivatives of ammonia, addition of alcohols, Cannizaro reaction, addition of Grignard reagents, products of Grignard

synthesis, acidity of α-hydrogens, reactions involving carbanion, base promoted halogenation of ketones, acid catalyzed halogenation of ketones, Aldol condensation, dehydration of aldol products, use of aldol condensation in sythesis, crossed aldol condenstion, Wittig reaction, Claisen condensation. 11 hrs.

Carboxylic Acids: Structure, nomenclature, physical properties, salts of carboxylic acides, industrial source, preparation, Grignard synthesis, nitrile synthesis, reactions, ionization of carboxylic acid, acdity of carboxylic acids, structure of carboxylate ions, effect of substituents on acidity, conversion into esters, acid chlorides and amides, reduction to alcohols, dicarboxylic acies, carbanions in organic synthesis, Malonic ester synthesis of carboxylic acids, Acetoacatic ester synthesis of ketones, Decarboxylation of β-keto acids and malonic acids **10 hrs.**

Amines: Structure, classification, nomenclature, physical properties, industrial source, preparation, reduction of intro compounds, amminolysis of halides, reductive amination, Hoffmann rearrangement, basicity of amines, structure and basicity, effect of subsituents of bisicity of aromatic amines, ring substitution in aromatic amines, reactions of amines with nitrous acid, diazonium salt, sandmeyer reaction, synthesis of phenol, diazonium salt (replacement by-H), synthesis using diazonium salts, synthesis of azocompounds. **8 hrs.**

Phenols: Structure, nomenclature, physical properties,salts of phenols, industrial source, preparation, reactions, acidity of phenols, Fries rearrangement, ring substitution, Kolbe's reaction, Riemer- Tiemann reaction, formation of aryl ethers.**5 hrs.**

Group C: Physical Chemistry

Chemical Kinetics: Concept of rate of a chemical reaction, measurement of reaction rate order and moleclularity of reaction, rate equation (differential and integral form) for zero, first and second order reactions, half life of a reaction, effect of temperature on the reaction rates, activation energy, qualitative treatment of collision theory of bimolecular reactions, activated complex theory, kinetic study of some reaction mechanism (reaction between O_2 and HBr, I_2 and propanone in acidic medium). **10 hrs.**

Catalysis: Types of catalysis, criteria of catalysis, activation energy and catalysis, poisons, promoters and inhabitors, theories of catalysis: Intermediate compound formation and adsorption theories, enzyme catalysis. **4 hrs.**

Photochemistry: Absorption of light, Lambert-Beer's law, Grothus Draper law, Stark Einstein law of photochemical equivalence, quantum yield, reason for high and low quantum yield, phosphorescence, fluorescence, chemiluminesence and thermoluminesence. **4 hrs.**

Conductance: Electrolytic conductance (specific, equivalent and molar conductances), determination of conductance, Kohlrausch's law of independent migration of ions, variation of conductance with dilution of weak and strong eletrolytes, transference number and its experimental determination using hittorfs and moving boundary method, applications of conductance measurement, determination of solubility and solubility product of sparingly soluble salt, degerr of dissociation and sissociation constant of acids, conductometric titration. **8 hrs.**

Electrochemical Cell: Electrolytic cell and galvanic cells, electronic concept of redox reactions, redox reaction and working of electrochemical cells, representation of electrochemical cells, half cells, single electrode potential and normal hydrogen electrode, measurement of standard electrode potential, electrochemical series, reference electrodes, measurement of emf of a cell, Nernst's equation, glass electrode, antimony electrode and quinhydrone electrode, potentiometric determination of pH potentiometric titration (acid base reaction), commercial cells: Leclanche dry cell, lead acid accumulator, fuel cells. **9 hrs.**

Thermodynamics: Molar heat capacities, relation between Cp an Cv, adiabatic expansion of an ideal gas for reversible and irreversible expansion, comparison between isothermal and adiabatic expansion, Joule's- Thompson effect, Inversion temperature, Carnot cycle thermodynamic efficiency, spontaneous and non-spontaneous changes, second law of thermodynamics, entropy and its mathematical derivation form Carnot cycle, entropy changes, irreversible process, entropy as a measure of randomness, entropy changes and unavailable heat, relation between enthalpy and entropy changes, free energy and work function and their significance, criteria of spontaneity and equilibrium in terms of entropy and free energy. **15 hrs.**

Course Title: Basic Practical Chemistry II **Full Marks:** 100
Course No.: CHEM 322 (major/minor) **Pass Marks:** 35
Nature of the course: Practical **Year:** II

Course Objectives:
The outcome of this course will be:

- to handle and manipulate chemical apparatus and materials safety.
- to record accurately and clearly the results of experiments.
- to draw conclusions and make generalizations from experiments.
- to apply appropriate chemical principle and make generalizations and predictions from chemical facts, observations an experiment data.

Gravimetric Analysis: Quantitative estimation of barium and sulphate ions as barium sulphate, iron as ferric oxide (Mohr's salt). **18 hrs.**

Inorganic Preparation: Prussian blue from iron fillings, cuprous chloride, tetra-ammine copper (II) sulphate, potassium trioxalato chromate, chrome alum. **33 hrs.**

Preparative Organic Chemistry: Single step preparation involving the following types methylation, esterification, acetylation, benzoylation, nitration, reduction, oxidation and azodyes preparation. These experiments should involve basic organic experiment techniques such as hot filtration, distillation under reduced pressure, filtration under partial vacuum etc. **51 hrs.**

Experiments on Physical Chemistry: Study the kinetics of hydrolysis of methyl acetate in presence of hydrochloric acid at room temperature, study the kinetics reaction reaction between

potassium persulphate and potassium iodide by iodine clock method, conductometric titration between strong acid and strong base, potenitiometric titration between acetic acid and sodium hydroxide using quinhydrone electrode and to determine dissociation constant of the acid, determination of heat of neutralization of hydrochloric acid with sodium hydroxide using Dewar flask/ polystyrene cup as calorimeters, determination of the heat of solution of potassium nitrite using Dewar flask/polystyrene cup as calorimeter. **48 hrs.**

Course Title: General Chemistry **Full Marks:** 100
Course No.: CHEM 331 (major) **Pass Marks:** 35
Nature of the course: Theory **Year:** III

Course Objectives:
The outcome of this course will be:

- to explain every day applications and uses of chemistry.
- to promote the students in the acquisition of knowledge and understanding of chemical patterns and principles.
- to present chemical ideas in a clear and logical form.
- to evaluate the environmental and technological implications of chemistry.

Group A: Inorganic Chemistry

Hydrogen: Isotopes of hydrogen, general study of hydrides and their classification. **5 hrs.**

Noblegases and their compounds: Preparation, properties and structure of xenon fluorides and oxo-compounds (Valence bond treatment, VSEPR treatment, molecular orbital treatment for XeF_2). **5 hrs.**

Detailed study of preparation, properties, bonding and structures of the followings: Boric acid, borates, boron nitride, borazines, boron hydrides, metal borohydrides, silicates, silicones, silanes, and siloxanes, interhalogen compounds, pseudohalogens, pseudohalides. **18 hrs.**

Chemical Fertilizers: Nitrogen fixation and synthetic fertilizers. **8 hrs.**

Reaction in nonaqueous solvents: Reactions of NH_3, reactions of SO_2. **6 hrs.**

Environmental Pollution: An elementary study of environmental pollution (in air and water) arising due to the presence of dust, carbon, CO, CO_2 NO_x, SO_x, H_2S, Use of ion-exchangers. **8 hrs.**

Group B: Organic Chemistry

Reaction mechanism and methods for determining: Types of mechanism, types of reaction, thermodynamic and kinetic requirements for reaction, the Baldwin's rules of ring closure, kinetic and thermodynamic control, the Hammond postulate, microscopic reversibility, methods of determining mechanism, identification of products, determination of the presence of an intermediate, the study of catalysis, isotope labeling, stereochemical evidence, rate expression for first and second order reaction, isotope effect. **8 hrs.**

Reactive Intermediates: Stability, structure, generation and fate of carbocation, carbanion, free radical, carbene, nitrene and benzyne, non classical carbonium ion, neighboring group praticipation by π and σ bonds, aromaticity and anti-aromaticity. **14 hrs.**

Spectroscopy and Structure: Determination of structure (spectroscopic methods), the mass spectrum, the electromagnetic spectrum, the infrared spectrum, infrared spectra of hydrocarbons and alcohols, the ultraviolet spectrum, the nuclear magnetic resonance (NMR) spectrum, chemical shift, peak area and proton coupling, spin-spin coupling, coupling constant, C-13 NMR (CMR) spectroscopy, CMR splitting, CMR chemical shift, PMR and CMR of hydrocarbons, alcohols and ethers. **11 hrs.**

Carbohydrates: Introduction, definition and classification, (+) – glucose as an aldohexose, (-)- fructose as a 2- keto

hexose, stereoisomers of (+) – glucose, oxidation (effect of alkali, osazone formation (epimers), lengthening and shortening the carbon chain of aldoses, conversion of an aldose into its epimer, conversion of aldose into ketose and vice-versa. configuration of (+) – glucose (the Fischer proof), configuration of aldoses, optical families D and L, tartaric acid families of aldoses (absolute configuration), open and cyclic structure of glucose, configuration about C-l, methylation, determining ring size, conformation. **11 hrs.**

Heterocyclic System: Structure of pyrrole, furan and thiophene, source of pyrrole, furan and thiophene, electrophilic substitutions in pyrrole, furan and thiophene (reactivity and orientation), staurated five memebered heterocycles, structure of pyridine, source of pyridine compounds, react ions of pyridine, nucleophilic substitution in pyridine electrophilic substitution in pyridine, basicity of pyridine, reduction of pyridine. **7 hrs.**

Group C: Physical Chemistry

Electrochemistry: Failure of Arrhenius theory in case of strong electrolyte, qualitative treatment of Debye Huckel Onsagar equation, activites and activity coefficients of strong electrolyte, ionic strength, qualitive treatment of Dybye Huckel limiting law., EMF of a cell: Reversible and irreversible cells, types of electrodes (convention regarding sign of emf, measurement of emf of a cell, thermodynamics and emf: $\triangle H$ and $\triangle S$ from emf, potential and equilibrium constants, thermodynamics of electrode potential, standard potential and equilibrium constants, chemical cells without transference and with transference, concentration cells with and without transference, liquid junction potential (no derivation), principles of photoelectrochemical cells. **20 hrs.**

Phase Equilibrium: Terminology, Gibbs phase rule, one component system: the water system, the sulphur system, two component system: the bismuth-cadmium system, simple eutectic diagram.
Liquid Mixture: Ideal and non ideal liquid mixture, distillation of binary liquids, ratio of distillate to residue, fractional distillation, azeotrope Solubility of partially miscible liquid pairs, maximum and minimum solution temperatures, Henry's law, distribution law, distribution of solute between two phases, solvent extraction. **15 hrs.**

Surface Chemistry: Physical adsorption and chemical adsorption, adsorption isotherms, Freundlich isotherms, derivation of Langmuir adsorption isotherms, B.E.T. equation and its use in surface area determination.
Colloids: Electrical double layer: Helmholtz and diffuse layers, zeta potential, lelectrophoresis, electroosmosis, precipitation of sol, gold number, Hardy Schutlz law, association of colloids, cleansing action of soap and detergents, emulsion and gels, solution of macromolecules, determination of molecular weight of maromolecules by (a) osmotic pressure (b) viscosity and (c) sedimentation method.

Course Title: General Practical Chemistry I **Full Marks:** 50
Course No.: CHEM 332 (major) **Pass Marks:** 20
Nature of the course: Practical **Year:** III

Course Objectives:
The outcome of this course will be:

- to handle and manipulate chemical apparatus and material safely.
- to make accurate observation and measurements, being aware of possible sources of error.
- to plan and organize simple experimental investigations to test hypotheses.
- to perform numerical calculations in which guidance on the methods of solution is provided.

Qualitative analysis of salt mixture containing not more than 6 ionic species (excluding salts insoluble in acids) out of the followings: Pb^{+}, Hg^{++}, Ag^{+}, Hg^{+}, Bi^{+++}, Cu^{++}. Cd^{++}, As^{+++}, Sb^{+++}, Sn^{++}, Fe^{++}, Fe^{+++}, Cr^{+++}, Al^{+++}, Co^{++}, Ni^{++}, Mn^{++}, Zn^{++}, Ba^{++}, Ca^{++}, Sr^{++}, Mg^{++}, K^{+}, NH_4^{+}, CO_3^{--}, S^{--}, SO_3^{--}, S_2O_3, CH_3COO^{-}, F^{-}, Cl^{-}, Br^{-}, I^{-}, NO_3^{-}, SO_4^{--},$C_2O_4^{--}$, PO_4^{---}, BO_3^{---} **33 hrs.**

Complexometric titration: Determination of Zn^{++}, Mg^{++}, Ca^{++}, and total hardness of water using EDTA. **18 hrs.**

Qualitative analysis of organic compounds: Systematic qualitative analysis of simple monofunctional organic compounds (aldehyde, ketone, carboxylic acid, carbohydrate, phenol, hydrocarbon, amine, intro, amide and ammonium salt). **51 hrs.**

Experiments on Physical Chemistry: Determination of the transition temperature of hydrated sodium sulphate

($Na_2SO_4 \cdot 10H_2O$), Determination of the dritical solution temperature of phenol-water system and the composition of the solution at CST, determination of the partition coefficient of iodine in chloroform and water, determination of the equivalent conductance at infinite dilution of strong electrolyte by conductance measurement, determination of ionization constant of acetic acid by pH-measurement and to verify Ostwald's dilution law. **48 hrs.**

Course Title: General Chemistry II **Full Marks:** 100
Course No.: CHEM 333 (major) **Pass Marks:** 35
Nature of the course: Theory **Year:** III

Course Objectives:
The outcome of this course will be:

- to develop student's ability to communicate in appropriate ways.
- to encourage students to apply their chemical knowledge and understanding to familiar and unfamiliar higher studies in chemistry.
- to pursue higher studies in chemistry.
- to explain the social, economic, environmental and technological implications of chemistry.

Group A: Inorganic Chemistry

Coordination Compounds: Isomerism in coordination compounds JUPAC nomenclature of coordination compounds, factors influencing the formation of complexes (thermodynamic and kinetic stability). **7 hrs.**

Bonding and application of coordination compounds: Valence bond theory, inner and outer orbital complexes, crystal field theory, characterization of complexes by spectroscopic, optical, magnetic, chelates and polynuclear complexes, stereochemistry of complexes with coordination number 4 and 6, substitution reactions & trans effect, application of complexes in analytical and biological fields. **20 hrs.**

Lanthanides and Actinides: Electronic structure, oxidation, states, colour and spectra, magnetic properties, lanthanide contraction. **5 hrs.**

Elementary study of carbonyls and nitrosyls: General method of preparation, bonding, application of 18 electron rule structure of carbonyls. **6 hrs.**

Organometallic Compounds: Non Transition metals: General Survey of their types, synthetic methods, metal alkyls of group I, II and III elements. Transition metals:- transition metals to carbon σ bonds, Alkene Complexes, haptonomenclature, alkyne complexes, allyl complexes, metallocenes (preparation, properties, structure and elementary approach of bonding with reference of ferrocene). **9 hrs.**

Bioinorganic Chemistry: Introduction, metals in biological system, a study of Fe in biological system. **5 hrs.**

Group B: Organic Chemistry

Name Reactions: Introduction study of glossary of at least 40 name reactions, their simple mechanism and the utilities of the synthetic reagents involved therein under the following heading of reaction types: oxidation-reduction, condensation, substitution, rearrangement, addition & elimination (names are given in the appendix I). **15 hrs.**

Principle of Organic Synthesis: Protecting groups, retrosynthetic analysis, retorn and synthon, multistep synthesis. **10 hrs.**

Lipids: Lipids, occurrence and composition of fats, hydrolysis, of fats, fats as a source of pure acids and alcohols, detergents, unsturated fats, phosphoglycerides, cell membrance, steroids. **6 hrs.**

Proteins and Nucleic Acid: Protein, structure of amino acids, amino acids as dipolar ions, isoelectric point, configuration of

natural amino acids, preparation of amino acids, reactions of amino acids, peptides (geometry of peptide linkage), determination of structure of peptides, synthesis of peptides, proteins (classification and functions), structure of protein, peptide chain, side chain (isoelectric point, electrophoresis), conjugated proteins, secondary structure of protein, uncleoproteins and nucleic acids, the genetic code. **11 hrs.**

Bio-organic Chemistry: Biological oxidation and reduction, (ethanol and acetaldehyde), biological oxidation and reduction (deuterium leballing experiments), stereochemistry of biological oxidation and reduction, organic chemistry of vision, biosynthesis of fatty acids, mechanism of enzyme action (chymotrypsin). **8 hrs.**

Group C: Physical Chemistry

Chemical Energetics: Entropy, entropy change in isolated system, dependence of entropy on temperature, volume and pressure, entropy change in ideal gas, entropy of mixing, entropy change in physical and chemical transformations, third law of thermodynamics, third law and its significance, free energy, free energy change for reaction, Gibbs-Helmholtz equation, properties and significance of $\triangle G$, reaction isotherms, Clapeyron equation, Clausius-Claperyron equation, thermodynamics of equilibrium constant, Kp and Kc for gaseous system, properties of equilibrium constant, thermodynamic criteria of equilibria. **18 hrs.**

Kinetics: Consecutive reactions, parallel reactions, opposing reaction, effect of temperature on reaction velocity, the energy of activation, the collision theory of bimolecular and unimolecular reactions, chain reactions, transition state theory, kinetics of the following photochemical reactions: (a) hydrogen and chlorine (b) hydrogen and bromine. **18 hrs**

Crystal System: Seven crystal systems and fourteen Bravais lattices, Miller indices, designation of planes and interplanar distances for cubic systems, diffraction of X-rays by crystal, Bragg's equation, crystal structure of sodium chloride and potassium chloride, point defects; Frenkel and Schottky defects (qualitative idea only). **8 hrs.**

Molecular Spectroscopy: Electromagnetic spectrum, Basic ideas, rotation, vibration and electronic spectra of diatomic molecules, Raman spectra. **6 hrs.**

Course Title: General Practical Chemistry II **Full Marks:** 50
Course No.: CHEM 334 (major) **Pass Marks:** 20
Nature of the course: Practical **Year:** III

Course Objectives:
The main outcome of this course will be:

- to follow instructions for practical work.
- to make accurate observation and measurements being aware of possible sources of error.
- to record accurately and clearly the results of experiments.
- to draw conclusions and-make generalizations from experiments.
- to explain practical techniques, procedures and safe laboratory working practices.

Quantitative Estimation: Precipitation titration of silver nitrate a acidic media (Volhard Method), Redox titration involving potassium dichromate (Mohr's salt, determination of iron in hematite). **12 hrs.**

Gravimetric Analysis: Nickel as complex with dimethyl glyoxime, copper as cuprous thiocyanate, aluminium as oxinate, lead as lead chromate, magnesium as magnesium ammonium phosphate and pyrophosphate. **33 hrs.**

Paper chromatography: Qualitative analysis of some inorganic anions and cations by paper chromatography (two each) **6 hrs.**

Organic Practical: Spectral analysis (spectra of simple organic compound will be provided and students are required to interpret the given spectra and find out the structures of organic compounds., Two sets of multistep synthesis (2-3 steps synthesis)., Quantitative analysis of any two: (OH- group,

nitrogen, sulphur, gluscose, carbonyl group). Isolation of the following natural products (any two): lactose, caffeine, camphor, essential oil., Purification by thin layer chromatography/ column chromatography. **51 hrs.**

Physical Chemistry Practicals: Determination of rate constant of the hydrolysis of ethyl acetate by sodium hydroxide., Study of the kinetics of acid catalysed iodination of propanone., Verification of F h adsorption isotherm., Verification of Lambert- Beer's law and to determine the concentration of a solution. Verification of Ostwald dilution law by measuring the conductance of acetic acid at different concentration and to determine the dissociation constant of the acid. **48 hrs.**

Text Book: For all theoretical courses i.e. CHEM 311, 321, 331 and 333

1. J.D. Lee, ***Concise Inorganic Chemistry***, 4th Edition, ELBS with Chapman & Hall, 1991.
2. F.A. Cotton, G. Wilkinson & C. Gaus, ***Basic Inorganic Chemistry***, 3rd Edition, John Wiley & Sons (SEA), Pvt. Ltd., 1995.
3. R.T. Morrison & R.N. Boyd, ***Organic Chemistry***, 6th Edition, Prentice-Hall of India Pvt. Ltd., 1994.
4. J. March, ***Advanced Organic Chemistry***, 3rd Edition, Wiley Eastern Ltd., India, 1994.
5. S.H. Maron & C.F. Prutton, ***Principles of Physical Chemistry***, 4th Edition, Oxford & IBH Pub. Co., 1992.

Reference Books: For all theoretical courses i.e. CHEM 311, 321, 331 and 333

1. A. Sharpe, ***Inorganic Chemistry***, 2nd Edition, ELBS & Longman, Singapore, 1986, (recent edition)

2. R.D. Madan, Satya Prakash, ***Modern Inorganic Chemistry***, S. Chand & Company Ltd., 1994.
3. K.N. Upadhaya, ***A Text Book of Inorganic Chemistry***, 2nd Edition Vikash Publishing House Pvt. Ltd., 1995.
4. Lawry and Richardson, ***Mechanism and Theory in Organic Chemistry***, Haper and Row, New York, 1981.
5. I.L. Finar, ***Organic Chemistry***, Vol. I and Vol. II, Prentice Hall, London, 1955, (available recent edition)
6. C. Norman, ***Principles of Organic Synthesis***, 2nd Edition, Chapman and Hill, London, 1978, (recent edition)
7. Warren, ***Organic Synthes***, The Disconnection Approach, Wiley, New York, 1982.
8. House, ***Modern Synthetic Reactions***, 2nd Edition, W.A. Benjamin, New York, 1972.
9. L. Kapoor, ***Text Book of Physical Chemistry***, Macmillan India Ltd. Vol. I to Vol. IV, 1992.
10. Alberty, ***Physical Chemistry***, 6th Edition, Wiley Eastern Ltd., New Delhi, 1992.
11. S. Glasstone & D. Lewis, ***Elements of Physical Chemistry***, McMillan & Co. Ltd.
12. S. Negi & S. C. Anand, ***A Text Book of Physical Chemistry***, Wiley Eastern Ltd., 1991.
13. R.M. Silverstein, G.L. Bassler & T.C. Morril, ***Spectrometric Identification of Organic Compounds***, Wiley, New York, 1981. (Preferable available recent edition)
14. C. Agrawal, ***Modern Inorganic Chemistry***, Wiley Eastern, New Delhi, 1981. (available recent edition)
15. Streitweiser & Heathcock, ***Introductory Organic Chemistry***, Wiley and Sons, New York, 1981.
16. Solomons, ***Organic Chemistry***, 3rd Edition, Wiley, New York, 1984.
17. R.A. Bansal, ***A Text Book of Organic Chemistry***, 2nd Edition, Wiley and Sons, New Delhi, 1993.

18. S. Bahl, G.D. Tuli & A., Bahl, ***Essential of Physical Chemistry***, S. Chand & Co., 1994.

Text Books: For all practical courses i.e. CHEM 321, 322, 332 and 334

1. A.I Vogel, ***A Text Book of Quantitative Inorganic Including Elementary Instrumental Analysis***, ELBS & Longman, 1969, (Preferably available recent edition)
2. A.I Vogel, ***A Text Book of Qualitative Inorganic Analysis***, ELBS & Longman, 1969, (recent edition)
3. R.L. Shriner, R.C. Fusion & D.Y. Cartin, **The Systematic *Identification of Organic, Compounds, A Laboratory Mani;al***, John Wiley and Sons, Inc., New York, 1986. (Preferably available recent edition)
4. B.P. Levitt, ed., ***Findlay's Practical Physical Chemistry***, Longman, London, 1973.

Reference Books: For all Practical courses i.e. CHEM 312, 322, 332 and 334

1. Gurdeep Raj, ***Advanced Practical Inorganic***, 10th Edition, Gel Publishing House, Meerut, 1994.
2. A.I. Vogel***, A Text Book of Practical Organic Chemistry***, Including Qualitative Organic Analysis, Longmans, 1958. (Preferably available recent edition)
3. F.G. Mann and B.C. Saunders, ***Practical Organic Chemistry***, Orient Longman, 1986. (Recent edition)
4. D.P. Shoemaker & C.W. Garland, ***Experiments in Physical Chemistry***, McGraw Hill, Kogakusha Ltd., Tokyo, 1967.
5. B.D. Khosla, A. Gulai & V.C. Garg, ***Senior Practical Physical Chemistry***, 5th Edition, S. Chand & Co., New Delhi, 1987.

Appendix: I

List of Name Reactions

Condensation reactions

1. Aldol condensation
2. Claisen condensation
3. Dickmann condensation
4. Darzen's condensation
5. Perkin condensation
6. Wittig reaction
7. Mannich reaction
8. Roformatsky reaction

Reduction reactions

1. Birch reduction
2. Clemmensen reduction
3. Wolff-Kishner reduction
4. Cannizzaro reduction
5. Metal hydride reduction
6. Catalytic hydrogenation

Elimination reaction

1. Hofmann degradation
2. E1, E2 and EICB reaction

Electrophilic substitution bonds

1. Friedel – Craft's reaction
2. Reimer – Tiemann reaction

Addition to hetero multiple bonds

Rearrangement reactions

1. Beckmann rearrangement
2. Claisen rearrangement
3. Cope rearrangement
4. Fovorskii rearrangement
5. Hofmann rearrangement
6. Pinacol rearrangement
7. Wagner – Meerwein rearrangement
8. Witting rearrangement

Oxidation rations

1. Baeyer-Villiger reaction
2. Oppenauer oxidation
3. Lead tetraacetake oxidation
4. Chromic acid oxidation
5. Permanaganate Oxidation
6. Peracid oxidation
7. Hydroboration Oxidation

Nucleophilic Substitution

1. SN1 and SN2 reaction
2. Grignard reaction
3. Wittig reaction
4. Malonic ester synthesis
5. Acetoacetic ester synthesis
6. Aromatic uncleophilic substitution

Addition to carbon-carbon multiple

1. Michalel Reaction
2. Diel's Alder reaction