SEMESTER I

PAPER E 101 GENERAL CHEMISTRY (Total Marks 75) 60

Unit 1.1 Structure of matter (Marks 20)

Origin of quantum theory – Black body radiation , Photoelectric effect – quantization of energy. Calculations based on Bohr's theory of H-atom – atomic spectra of hydrogen. Qualitative treatment of dual nature of matter (de Broglie equation), Heisenberg's uncertainty principle, Schrodinger's time independent equation, physical interpretation of the wave function. Solution of Schrodinger equation for the electron of H-atom (qualitative idea only), quantum numbers, orbital, Radial function and angular function, plots of radial function (qualitative idea only), effective nuclear charge, energy of the orbitals. Electron spin and spin quantum number.

Many electron atoms – electronic configuration – aufbau principle, Pauli's principle, Hund's rule.

Unit 1.2 Covalent bonding (Marks 15)

Valence bond approach : Lewis electron pair bonds (H_2, HF, O_2, N_2, CO, NO, NH_3, H_2O, H_2O_2). Shapes of molecules – principle and applications of valence shell electron pair repulsion theory (Examples : BF_3, CH_4, NH_3, H_2O, PCl_5, SF_6, XeF_4, IF_7). Hybridisation (in BeH_2, C_2H_2, C_2H_4, CH_4, BF_3, CO_3^{2-}, PCl_5, SF_6 and benzene). Resonance (in benzene, O_3, CO_3^{2-}, NO_3^-), resonance energy, delocalization in benzene.

Polar molecules – the concept of electronegativity (Pauling and Mulliken scale). Dipole moment and bond moment (CO_2, H_2O, NH_3, NF_3). Percentage ionic character of bonds (in HF, HCl, HBr).

Unit 1.3 Ionic bonding and intermolecular forces (Marks 8)

Ion pairs and ionic bond, properties of ionic compounds, lattice energy (Example NaCl). Calculation of lattice energy and heats of formation of ionic compounds using Born-Haber cycle. Ionic radii and factors effecting ionic radius, radius ratio and structure of ionic crystals. Covalency in ionic compounds – Fajans rules. Results of polarization on melting points, boiling points and solubility.

Intermolecular forces, hydrogen bond, structure of ice.

Unit 1.4 States of matter (Marks 22)

Postulates of kinetic theory of gases – derivation of expression for pressure from kinetic theory. Calculation of rms speed and average kinetic energy. Maxwell's distribution of molecular speeds (no derivation) – effect of temperature and molar mass of gas.

Deviation from ideal behaviour, van der Waals equation of state, critical constants and their derivation from van der Waals equation.

Heat capacities of gases, degrees of freedom, principle of equipartition of energy.

Structure of liquids, kinetic molecular model and properties of liquid. Definition and experimental measurement of vapour pressure (dynamic method), surface tension (drop number method) and viscosity (Ostwald method). Variation of these properties with temperature.

Crystal lattices, unit cells of the seven crystal systems. Density of cubic unit cell. The fcc, bcc and simple cubic systems. Closed packed structures. Imperfections in solids (introduction to Schottky and Frenkel defects)

Internal Assesment **(Marks 10)** 15

SEMESTER – II

PAPER 201 GENERAL CHEMISTRY (Total Marks 75)

Unit 2.1 Hydrocarbons I (Marks 20)

(a). Introduction to classification and nomenclature of organic compounds on the basis of their functional groups

(b). Alkanes : Preparation (Wurtz, Kolbe, Corey-House reactions) and their properties and reactions. Homolytic bond fission. Free radical generation and reactivity. Photochlorination of alkanes.

(c). Cycloalkanes : preparation of cyclopropane, cyclobutane, cyclopentane, cyclohexane. Strain theory and stability. Reactions of cyclopropane.Conformations of cyclohexane, disubstituted cyclohexane. Free rotation of σ-bonds, rotamers of n-butane, their nomenclature and stability.

(d). Alkenes : Preparation (elimination of alkyl halides, alcohols, Wittig reaction, pyrolysis of esters). Reactions of alkenes. π-diastereomerism, stability and interconversion. Markownikov and Zaitzeff rule. Mechanism of electrophilic addition reaction.

(e). Alkynes and alkadienes : Preparation, properties, reactions of alkynes (ethyne, propyne, butyne as example). Addition reactions of alkynes with polar reagents, ozonolysis, catalytic hydrogenation (Lindlar's catalyst). Preparation of 1,3-butadiene and isoprene. 1,2- and 1,4-addition of conjugated dienes.

Unit 2.2 Hydrocarbons II (Marks 15)

(a). Reactive intermediates: carbocations and carbanions – their shape, generation, stability and reactions

Stereochemistry : Classification – geometrical (simple examples involving alkenes,

cis-trans and *E-Z* nomenclature) optical and conformational isomers. Basic concepts of erythro and threo isomers, asymmetry, enantiomerism, diastereomerism, dissymmetry, meso structures. Chirality and prochirality. Racemization, racemic mixtures, resolution of racemic mixtures. D-L and R-S notation.

(b). Alkyl halides and 1,2-dihalides : Preparation, properties and reactions of alkyl halides. Mechanism of S_N1 and S_N2 reactions, E_1 and E_2 reactions. Effect of solvent, substrate and other factors on the mechanism. Substitution vs elimination. Conversion of alkyl halides to alcohols, ethers, amines, thioethers and thiols. Preparation and synthetic uses of Grignard reagent.

Unit 2.3 Hydrocarbons III (Marks 8)

(a). Preparation and synthetic uses of diazomethane, ketene.

(b). Aromatic hydrocarbons : IUPAC nomenclature. Aromaticity. Preparation and reactions of benzene. Mechanism of electrophilic aromatic substitution. Activation, deactivation and directive influence of groups. Conversion of benzene to its derivatives and vice versa. Preparation and properties of naphthalene, anthracene.

Unit 2.4 Chemical Thermodynamics (Marks 15)

Basic definitions and concepts. The zeroth law, nature of work and heat. The first law of thermodynamics – enthalpy and internal energy. Relation between C_p and C_v. Relation between P, V and T in adiabatic processes.

Thermochemistry – enthalpy of reaction, relation between H and U. Standard enthalpy changes. Hess law and Kirchhoff's law. Calculation of bond energy from thermodynamic data.

The second law of thermodynamics. Carnot cycle. Enttropy and spontaneity, calculation of entropy changes during vapourisation and fusion. Trouton's rule. Free energy, standard free energy and its significance, dependence of free energy on temperature and pressure. Free energy change and equilibrium constant. Thermodynamic criteria for chemical equilibria.

Unit 2.4 Phase Rule (Marks 7)

Definition of phase, component and degrees of freedom. Phase rule. Phase diagram of water and sulphur systems.

Ideal and non-ideal solutions.

Principle of fractional distillation of liquid-liquid mixtures, azeotrope.

Internal Assesment **(Marks 10)** (15)

SEMESTER III

PAPER E 301 GENERAL CHEMISTRY (Total Marks 50)

Unit 3.1 Chemistry of non-transition elements I **(Marks 13)**

Groupwise study of physical properties, chemical reactivity of elements and their important compounds- oxides and hydroxides, oxyacids, halides, hydrides (Groups 1,15,16,17).

Periodicity : General trends in size, ionization energy, electron affinity and electronegativity, first and second row anomalies, diagonal relationships, the use of d-orbitals by third period elements, catenation and inert pair effect (in Pb and Tl).

Inorganic chains, rings and cages: Synthesis, structure and reactions of silicones, borazine and Diborane.

Unit 3.2 Chemistry of non-transition elements II **(Marks 5)**

Carbides and Nitrides. Interhalogen compounds, polyhalides, pseudohalogens-synhesis and structure. Noble gas compounds-synthesis, structure and bonding.

Unit 3.3 Transition elements **(Marks 14)**

Comparative study of elements of first transition series with emphasis on electronic configuration, relative stability of oxidation states , ionization potentials, redox potentials, reactivity.

Occurrence, principles of extraction of Cr, Mn and Ni and their important compounds (example-$KMnO_4$,$K_2Cr_2O_7$).

Werrner theory, types of ligands, Isomerism and IUPAC nomenclature of coordination complexes. Chelates.

Essential and trace elements useful to life and an introduction to their biological role. Toxicity due o metals and non-metals. Use of metal compounds in medicine.

Unit 3.4 Electrochemistry **(Marks 13)**

Galvanic cells-description and working process. Standard electrode potentials and electromotive force(emf).The Nerst equation and calculation of cell potential.Concentration cells. Relation between cells emf and equilibrium onstant. Standard and reference electrodes. Measurement of pH. Commercial applications of galvanic cells-dry cell, lead storge battery, fuel cells.

Conductance of electrolytes- specific ad molar conductance. Measurement of conductance and application of conductance measurement. Conductometric titrations. Variation of molar conductivity with concentration . Kohlrausch's law of independent migration of ions. Transport number of ions and their determination.

Internal Assesment **(Marks 5)** (10)

PAPER E 302 PRACTICAL **(Total Marks 50)**

1. Qualitative Organic Analysis **(Marks 25)**

a) Detection of N, S and halogens in organic compounds.

b) Detection of functional groups (one among the following)

-OH(alcoholic), -OH (phenolic), -CHO, C=O, -COOH, $-NO_2$, $-NH_2$, hydrocarbon,

(Students have to perform analysis of at least 5 liquid and / or solid organic samples and record the results systematically in practical note book)

2. General experiments **(Marks 10)**

a. Paper chromatographic separation of cations of Group I

b. Determination of the solubility of a salt at a given temperature.

(In the examination, any one of the above experiment will be allotted by lot)

3. Sessional examination **(Marks 10)**

(Marks to be awarded by holding an examination at the end of the session)

4. Viva - voce **(Marks 5)**

SEMESTER IV

PAPER E 401 GENERAL CHEMISTRY (Total Marks 50)

Unit 4.1 Aliphatic and aromatic hydroxyl compounds and ethers (Marks 10)

Classification of alcohols, 1^0, 2^0, 3^0 alcohols and their distinguishing reactions. General methods of preparation, properties and general reactions of primary alcohols, glycols and glycerol. Basic concept of hydrogen bonding and their influence on properties of organic compounds. Willamson's ether synthesis and hydrolysis of ethers.

Benzyl alcohol-preparation and reaction. Synthesis and reactions of phenols. Acidity of phenols and substituted phenols. Electrophilic aromatic substitution ofphenols. Synthesis of Bakelite.

Unit 4.2 Aliphatic amines and aniline (Marks 4)

1^0, 2^0, 3^0 amines. Basicity of amines. Preparation , properties and reactions of 1^0 amines. Synthesis, properties and reactions of aniline. Basicity of aniline and substituted aniline. Electrophilic aromatic substitution. Diazonium ions and their synthetic utility.

Unit 4.3 Aliphatic and aromatic carbonyl compounds (Marks 5)

General methods of preparation and reactions of carbonyl compounds(formaldehyde, acetaldehyde, acetone and 2-butanone as example). Difference in reactivity of aldehyde and ketones. Polarization of carbonyl group. Nucleophilic addition of aldehydes and ketons, mechanism with examples. Preparation and reactions of benzaldehyde and acetophenone.

Unit 4.4 Aliphatic and aromatic carboxylic acids (Marks 4)

Acidity of carboxylic acids, and substituted carboxylic acids. General methods of preparation , properties and reactions of aliphatic carboxylic acid(methanoic ethanoic and propanioc acid as examples)

Synthesis , properties and reactions of benzoic acid. Acidity of substituted benzoic acids. Conversion of carboxylic acids to their derivatives.

Synthetic uses of ethylacetoacetate and diethylmalonate.

Unit 4.5 Amino acids, carbohydrates, fats and oils (Marks 4)

Elementary ideas of amino acids, essential amino acids,optical activity, DL nomenclature. Synthesis and reaction of glycine. Simple methods of preparation of dipeptides.

Monosaccharides: Open chain and ring structure of glucoscand fructose. Concept of mutarotation, anomers, epimers. Reaction of glucose and fructose.

Structure, physical properties and differences of Fats, Oils and Soaps. Analysis of Fats and Oils

Unit 4.6 Chemical kinetics and surface chemistry
(Marks 13)

Reaction rates and rate laws. Order and molecularity of a reaction. Differencial and integrated rate equation of first and second order reactions. Experimental determination of reaction rates and order of reaction. Consecutive reactions. Chain Reactions. Steady state approximation. Effect of temperature on reaction rate, Arhenius equation. Collision throry of reaction rate(qualitative treatment only)

Homogeneous catalysis, acid base catalysis.Physisirption and chemisorption. Freundlich and Langmuir adsorption aisotherms, their validity and significance. Heterogeneous catalysis-adsorption theory (qualitative treatment only).

Colloids-Classification, preparation and purification, structure and stability.

Surfactants-definition, micelle formation and critical micelle concentration.

Unit 4.6 Ionic equilibrium
(Marks 5)

Dissociation equilibria of weak electrolytes, Ostwald's dilution law, strengths of acids and bases. Solubility products and application in analytical chemistry.pH and pH scale. Henderson-Hasselbach equation and calculation of pK values. Buffer solutions and buffer action, uses of buffer solutions in chemistry and biology.

Internal Assesment **(Marks 5)** (10)

PAPER E 402 PRACTICAL (Marks 50)

1. Qualitative Inorganic Analysis **(Marks 15)**

Identification of not more than 3 radicals in a mixture of the following :

Cation : Hg^{2+}, Pb^{2+}, Cu^{2+}, Bi^{2+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}/Sn^{4+}, Fe^{2+} Fe^{3+}, Cr^{3+}, Al^{3+}, Co^{2+},

Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+}

Anions : Cl^-, Br^-,I^-, NO^-_2, NO_3^-, S^{2-}, SO_4^{2-}, F^-, BO_3^{3-}, PO_4^{3-}, AsO_4^{3-}

(Presence of Na^+, K^+, NH_4^+ and CO_3^{2-} radicals are to be ignored and not to be reported)

(At least 4 salt mixtures have to be done by each student in practical class keeping records

carefully. Distribution of marks : Result 5x3=15 marks)

2. Quantitative Inorganic Analysis **(Marks 20)**

Estimation by volumetric method of any one of the following :

a. Fe (II)- By standard $KMnO_4$ solution

b. Fe (III) – By standard $K_2Cr_2O_7$ solution

c. Cu (II) – By Iodometric method.

(Standardization will have to be done by each student and will be required to be reported.)

(Distribution of Marks : Preparation of standard solution -3 marks, Standardization/ Reduction -4 marks, Completion of experiment -5 marks, and Result-8 marks)

3. Sessional examination **(Marks 10)**

(Marks to be awarded by holding an examination at the end of the session)

4. Viva - voce **(Marks 5)**

SEMESTER V

PAPER E 501 GENERAL CHEMISTRY **(Total Marks 100)**

Unit 5.1 Chemistry of materials **(Marks 15)**

Electrical properties of solids : Band theory (from MO theory), conductors, insulators and semi-conductors. Intrinsic and extrinsic semiconductors (examples from chemical compounds and explanation of electrical property from band theory). Superconductivity and examples of superconducting materials, Ferroelectric and Piezoelectric materials, Preparation of electronic grade pure silicon.

Magnetic properties of solids : Ferro and antiferro magnetism (examples from chemical compounds).

Applications of clays, geolites, ceramics, glass and liquid crystals.

Unit 5.2 Principles of chemical analysis **(Marks 15)**

Principles of separation and identification of a mixture of cations and anions (qualitative

analysis). Application of solubility product and Common ion effect in chemical analysis.

Principles of estimation of metals quantitatively by complexometric methods. Principle of acid-base titration. Theory of indicators.

Principle and application of solvent extraction. Basic principles of chromatography, nature of adsorbent, solvent system; R_f values. Different types of chromatographic methods and their applications.

Unit 5.3 Principles and applications of spectroscopy-1 **(Marks 20)**

The nature of electromagnetic radiation, the regions of electromagnetic spectrum, the energy tionlevels of hydrogen atom (from Bohr's theory), the line spectrum of hydrogen.

Electronic spectroscopy : The Beer-Lambert law, Molar adsorption co-efficient and absorbance, the selection rules for electronic transition, the influence of vibrations in molecular spectra, Re-emission of energy by excited molecules (fluorescence and phosphorescence).

Structural elucidation by UV-Visible spectroscopy, Colour and electronic transitions. Quantitative estimation by Colorimetric method.

Vibrational Spectroscopiy : Introduction to vibrational energy levels in diatomic molecules, Fundamental vibrational modes of water molecule.

Conditions of Infrared and Raman activity in molecules, simple examples of structure elucidation by Infrared and Raman spectroscopy.

Unit 5.4 Principles and applications of spectroscopy-2 **(Marks 15)**

Basic principles of Mass Spectroscopy, Application of Mass Spectroscopy in structure elucidation of simple organic compounds.

Basic principles of Nuclear Magnetic Resonance (NMR) spectroscopy, representation of NMR spectra. Approximate Chemical Shifts of simple organic molecules and functional groups.

Unit 5.5 Nuclear chemistry **(Marks 15)**

Nuclear charge, isotopes and isobars, nuclear compositions, structure and properties (size, mass, binding energy and shape). Nuclear reactions –Radioactivity, rates of radioactive decay. Artificial radioactivity. Nuclear fission and fusion. Nuclear reactors.

Applications of Radioactivity; Radioisotopes and their uses, Radiocarbon dating, Nuclear medicines. Environmental hazard due to nuclear radiation.

Unit 5.6 Lanthanides and actinides **(Marks 10)**

Chemistry of Lanthanide and Actinide elements : Electronic configuration, oxidation states, properties, reactions and uses.

Internal Assessment **(Marks 10)**

PAPER E 502 PRACTICAL (Total Marks 100)

1. **Physical Practical** (any one of the following) **(Marks 40)**

(a). To study the distribution of iodine between two immiscible solvents at room temperature.

(b). To determine the water of crystallization in ferrous sulphate by titration with 0.1 N $KMnO_4$ solution.

(c). To determine the water of crystallization in hydrated salt by ignition and weighing.

(d). To determine coefficient of viscosity of a given liquid by Ostwald's viscometer.

(e). To study the CST of phenol-water system.

Distribution of Marks : Theory - 10, Reporting & Results – 20, Completion – 10.

2. Preparation of Organic compounds (Marks 35)

(a). Tribromoaniline from aniline

(b). Tribromophenol from phenol

(c). *m*-dinitrobenzene from nitrobenzene

(d). Benzil from benzoin

(e). Phthalic anhydride from phthalic acid

(f). Iodoform from acetone

(g). Osazone from glucose

Distribution of Marks : Yield & Quality - 20, Recrystallisation & melting point – 5, Completion – 10.

3. Sessional (Marks 10)

4. Viva (Marks 15)

SEMESTER VI

PAPER E 601 GENERAL CHEMISTRY (Total Marks 100)

[INDUSTRIAL, ENVIRONMENTAL AND BIOLOGICAL CHEMISTRY]

Unit 6.1 Industrial Chemistry – Inorganic (Marks 20)

Water : Modern methods of water treatment and purification.

Fertilisers : Different types of N and P fertilizers, manufacture of ammonia, ammonium nitrate, urea phosphates and superphosphates. Nitrogen fixation by plants.

Glass : Various types of glass fibers, optical glass, glazing and vitrification, glass ceramics.

Cement : Various types of cement, their composition and manufacture. Portland cement, setting of cement.

Paints : Constituents of different paints, Role of binder and solvent, Lead and Zinc containing paints. Paints of common use.

Metals and Alloys : General procedure of extraction of metals. Manufacture, properties, composition and uses of important alloys. Manufacture of steel and stainless steel. Galvanisation, rusting and corrosion.

Unit 6.2 Industrial Chemistry – Organic (Marks 20)

Polymers : Types of polymers and polymerization process. Manufacture, structure, properties and applications of –

a. Synthetic rubber (including principle of cross-linking and vulcanization)

b. Synthetic fibers

c. Plastics

d. Foaming agents

e. Resins

f. Silicones

Coal : Fisher-Tropsch process. Chemicals from coal.

Petroleum : Manufacture and industrial reactions of ethane, propane, butadiene, acetylene and xylene. Synthesis of methanol from natural gas. Cracking of petroleum.

knocking and octane number. Synthetic petrol, LPG and CNG. Biodiesel.

Oils, Fats and Detergents : Catalytic hydrogenation of vegetable oil and fat for production of soap, synthesis of detergents. Principles of cleansing action.

Enzymes in industries : Production of alcohol by fermentation of starch and sugar (reaction conditions, nature of enzymes used, structural transformation during reaction). Preparation and use of cellulose.

Unit 6.3 Environmental Chemistry (Marks 20)

Composition of the atmosphere. Photochemical reactions in the atmosphere. Vehicle exhausts and photochemical smog, Acid rain, Carbon monoxide and its effects, Suspended particulate matter – size and effects on health. Dual role of ozone in the atmosphere – tropospheric ozone and stratospheric ozone, ozone hole. Carbondioxide and other gases responsible for global warming. Measures to control air pollution.

Quality of water for drinking and other purposes. Permissible limits. Common water pollutants – organic and inorganic. Heavy metals and their toxic effects. Pollution of water through use of chemical fertilizers. Fluoride contamination and fluorosis. Pollution due to mining. Measures taken to control water pollution.

Unit 6.4 Biological Chemistry (Marks 15)

The cell and its components, the structure of cell membrane, transport of ions and molecules across the membrane. Transport of ions and molecules across the membrane.

Molecular structure and function of amino acids, peptides, polypeptides, conformations of proteins, primary, secondary, tertiary and quaternary structure of proteins.

Structure of purines and pyrimidines, base pairing hydrogen bonds, nucleosides and nucleotides. The double helical structure of DNA and structure of RNA. Basic ideas of gene and heredity. The genetic code and genetic mutation. Biosynthesis of DNA (replication), RNA (transportation) and protein (translation).

Enzymes and their role (with a few examples). Catalysis by enzymes, Lock-key hypothesis. Specificity of enzyme action, inhibition and denaturation.

Vitamins and their importance. Coenzymes, examples of various vitamins and coenzymes. Basic idea of nutrition.

Transformation of energy by cells : elementary idea of chemical reactions involved in glycolysis and Kreb's cycle, photosynthesis and respiration, oxidative phosphorylation.

UNIT 6.5 Natural products and medicines (Marks 15)

Terpenes : Classification, structure and isolation.

Alkaloids : Classification, structure and isolation. Physiological action of alkaloids.

Steroids and Hormones : Elementary introduction, structure functions of hormones, neutrotransmitters.

Medicines : Structure and uses of aspirin, quinine, penicillin, tetracycline. Sulpha drugs and the mechanism of their action. Cancer and anti-cancer drugs.

Internal Assesment **(Marks 10)**

PAPER E 602 Practical (Total Marks 100)

1. **Physical Practical** (any one of the following) **(Marks 40)**

(a). To determine the hardness of water by complexometric titration.

(b). To determine the equivalent mass of carboxylic acid titrimetrically.

(c). To study the kinetics of the reaction between $S_2O_3^{2-}$ and HCl (initial rate method).

(d). To study the kinetics of acid catalysed hydrolysis of ester (titrimetry).

(e). Conductometric titration between strong acid and strong base.

(Distribution of Marks : Theory - 10, Reporting & Results – 20, Completion – 10.)

2. **Preparation of Inorganic compounds (Marks 35)**

Double salt (chrome alum, Mohr's salt) and Complex (potassium trioxalatoferrate (III),

potassium trioxalatochromate(III))

(Distribution of Marks : Yield & Quality - 20, Qualitative test – 5, Completion – 10.)

3. **Sessional (Marks 10)**

4. **Viva (Marks 15)**
