transistors; Amplifiers and oscillators; Op-amps; FET, JFET and MOSFET; Digital electronics-Boolean identities, De morgan's laws, logic gates and truth tables; simple logic circuits; thermistors, solar cells, fundamentals of microprocessors and digital computers.

e. Digital electronics, Radar systems, Satellite communications:

Digital circuits, Number systems and codes, Combination logic circuits, sequential logic circuits, microprocessor architecture, functional diagram, Pin description, Timing diagram of read cycle, timing diagram of write cycle. Data transfer techniques-Serial transfer, parallel transfer etc. Radar systems, signal and data processing, satellite communication-Fundamentals Designing a surveillance radar, tracking radar, signal and data processing, radar antenna parameters, satellite systems-communication satellite systems, communication satellites, orbiting satellites, satellite frequency bands, satellite orbit and inclinations. Multiple access techniques, earth station technology.

f.Quantum Mechanics:

Wave-particle duality; Wave functions in coordinate and momentum representations; Commutators and Heisenberg's uncertainty principle; Matrix representation; Dirac's bra and ket notation; Schroedinger equation (time-dependent and time-independent); Eigen value problems such as particle-in-a-box, harmonic oscillator, etc.; Tunneling through a barrier; Motion in a central potential; Orbital angular momentum, Angular momentum algebra, spin; Addition of angular momentum; Hydrogen atom, spin-orbit coupling, fine structure; Time-independent perturbation theory and applications; Variational method; WKB approximation; Time dependent perturbation theory and Fermi's Golden Rule; Selection rules; Semi-classical theory of radiation; Elementary theory of scattering, phase shifts, partial waves, Born approximation; Identical particles, Pauli's exclusion principle, spin-statistics connection; Relativistic quantum mechanics: Klein Gordon and Dirac equations.

CHEMISTRY PAPER-I (Inorganic Chemistry): 200 Marks

Chemical periodicity:

Periodic table, group trends and periodic trends in physical properties. Classification of elements on the basis of electronic configuration. Modern IUPAC Periodic table. General characteristic of s, p, d and f block elements. Effective nuclear charges, screening effects, atomic radii, ionic radii, covalent radii. Ionization potential, electron affinity and electro-negativity. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements. General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties, catenation and catalytic properties, oxidation states, aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such hydrides, halides, oxides, oxy-acids, complex chemistry in respect of s-block and p-block elements.

Chemical Bonding and structure:

Ionic bonding: Size effects, radius ratio rules and their limitations. Packing of ions in crystals, lattice energy, Born-lande equation and its applications, Born-Haber cycle and its applications. Solvation energy, polarizing power and polarizability, ionic potential, Fazan's rules. Defects in solids. Covalent bonding: Lewis structures, formal charge. Valence Bond Theory, Molecular orbital Theory, hybridizations, VSEPR theory. Partial ionic Character of covalent bonds, bond moment, dipole moment and electro negativity differences. Concept of resonance, resonance energy, resonance structures. Schrodinger equation for the H-atom.

Coordinate bonding: Werner theory of coordination compounds, double salts and complex salts, Lewis acid-base. Ambidentate and polydentate ligands, chelate complexes. IUPAC nomenclature of coordination compounds. Coordination numbers, Geometrical isomerism. Stereoisomerism in square planar and octahedral complexes. Hydrogen bonding. Metallic bonding: qualitative idea of band theory, conducting, semi conducting and insulating properties.

Chemistry of coordination compounds:

Isomerism, reactivity and stability: Determination of configuration of cis- and trans- isomers by chemical methods. Labile and inert complexes, substitution reaction on square planer complexes, trans effect. Stability constants of coordination compounds and their importance in inorganic analysis. Structure and bonding: Elementary Crystal Field Theory: splitting of do configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy; pairing energy. Jahn- Teller distortion. Metal-ligand bonding, sigma and pi bonding in octahedral complexes and their effects on the oxidation states of transitional metals . Orbital and spin magnetic moments, spin only moments of and their correlation with effective magnetic moments, d-d transitions; LS coupling, spectroscopic ground states, selection rules for electronic spectral transitions; spectro-chemical series of ligands; charge transfer spectra .

Acid-Base reactions

Acid-Base concept: Arrhenius concept, theory of solvent system, Bronsted-Lowry's concept, relative strength of acids, Pauling rules. Lewis concept. Acidbase equilibria in aqueous solution and pH. Acid-base neutralisation curves; indicator, choice of indicators.

Precipitation and Redox Reactions:

Solubility product principle, common ion effect. Ion-electron method of balancing equation of redox reaction. Standard redox potentials, Nernst equation. Influence on complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram of common elements and their applications. Disproportionation and comproportionation reactions.

Organo metallic compounds:

18-electron rule and its applications to carbonyls, nitrosyls, cyanides, and nature of bonding involved therein. Simple examples of metal-metal bonded compounds and metal clusters. Metal-olefin complexes: zeises salt, Ferrocene.

Nuclear chemistry:

Radioactive decay - General characteristics, decay kinetics, parent -daughter decay growth relationships, determination of half-lives, Nuclear models -shell model, liquid drop model, Fermi gas model, Collective model and optical model. Nuclear stability. Decay theories. Nuclear reactions- fission, fusion and spallation reactions. Definition of curie and related calculations, preparation of artificial radionuclides by bombard-ment, radiochemical separation techniques. Experimental techniques in the assay of radioisotopes, gas filled detectors-ionization chamber, proportional and Geiger-Muller counters -G.M. Plateau, dead time, coincidence loss, determination of dead time, scintillation counters, solid state detectors.

s-Block Elements :

Hydride , hydration energies, solvation and complexation tendencies of alkali and alkaline-earth metals, principle of metallurgical extraction, Chemistry of Li and Be, their anomalous behaviour and diagonal relationships, alkyls and aryls.

p-Block Elements :

Comparative study of group 13 & 14 elements with respect to periodic properties. Compounds such as hydrides, halides, oxides and oxyacids; diagonal relationship; preparation, properties, bonding and structure of diborane, borazine and alkalimetal borohydrides. Preparation, properties and technical applications of carbides and fluorocarbons. Silicones and structural principles of silicates.

Chemistry of d- and f- block elements:

General comparison of 3d, 4d and 5d elements in term of electronic configuration, elemental forms, metallic nature, atomization energy, oxidation states, redox properties, coordination chemistry, spectral and magnetic properties. f-block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of lanthanides, comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method). Chemistry of some representative compounds: K2Cr2O7, KMnO4, K4[Fe(CN)6], K2[Ni(CN)4], H2PtC16, Na2[Fe(CN)5N0].

CHEMISTRY PAPER-II (Physical Chemistry) :200

Kinetic theory and the gaseous state:

Gaseous state: Gas laws, kinetic theory of gas, collision and gas pressure, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature. Maxwell's distribution of speeds. Kinetic energy distribution, calculations of average, root mean square and most probable velocities. Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

Collision of gas molecules, Real gases:

Collision diameter; collision number and mean free path; frequency of binary collisions; wall collision and rate of effusion. Real gases, Deviation of gases from ideal behaviour; compressibility factor; Andrew's and Amagot's plots; van der Waals equation and its characteristic features. Existence of critical state. Critical constants in terms of van der Waals constants. Law of corresponding state and significance of second virial coefficient. Boyle temperature. Intermolecular forces.

Liquid state: physical properties of liquids and their measurements: surface tension and viscosity

Solids: Nature of solid state, law of constancy of angles, concept of unit cell, different crystal system, Bravais lattices, law of rational indices, Miller indices, symmetry elements in crystals. X-ray diffraction, Bragg's law, Laue's method, powder method, radius ratio and packing in crystals.

Thermodynamics:

Definition of thermodynamic terms. Thermodynamic functions and their differentials. Zeroth law, First law and Second law of thermodynamics. Cyclic, reversible and irreversible processes. Internal energy (U) and enthalpy

(H); relation between Cp and Cv, calculation of w, q, ?U and ?H for expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion. Joule-Thomson Coefficient and inversion temperature. Application of First law of thermodynamics.

Application of Second law of thermodynamics.

Carnot cycle and its efficiency, Gibbs function (G) and Helmholtz function (A), Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of a process. Chemical equilibrium: chemical equilibria of homogeneous and heterogeneous systems, derivation of expression of equilibrium constants, Le Chatelier's principle of dynamic equilibrium.

Thermodynamics and Equilibrium:

Chemical potential in terms of Gibb's free energy and other thermodynamic state functions and its variation with temperature and pressure. Gibbs-Duhem equation; fugacity of gases and fugacity coefficient. Thermodynamic conditions for equilibrium, degree of advancement. Van't Hoffs reaction isotherm. Equilibrium constant and standard Gibbs free energy change. Definitions of KP, KC and Kx; van't Hoffs reaction isobar and isochore. Le Chatelier's principle. Activity and activity coefficients of electrolyte / ion in solution. Debye-Huckel limiting law.

Acids-bases and solvents:

Modern aspects of acids and bases: Arrhenius theory, theory of solvent system, Bronsted and Lowry's concept, Lewis concept with typical examples, applications and limitations. Strengths of acids and bases. Ionization of weak acids and bases in aqueous solutions, application of Ostwald's dilution law, ionization constants, ionic product of water, pH-scale, buffer solutions and their pH values, buffer actions & buffer capacity; hydrolysis of salts.

Solutions of non-electrolytes: Colligative properties of solution, Raoult's Law, relative lowering of vapor pressure, osmosis and osmotic pressure; elevation of boiling point and depression of freezing point of solvents.

Chemical kinetics and catalysis:

Order and molecularity of reactions, rate laws and rate equations for first order and second order reactions; zero order reactions. Parallel and consecutive reactions. Determination of order of reactions. Temperature dependence of reaction rate, energy of activation. Enthalpy of activation, entropy of activation , effect of dielectric constant and ionic strength of reaction rate, kinetic isotope effect; collision theory & transition State Theory of reaction rate, Catalytic reactions.

Adsorption and Surface Chemistry:

Physisorption & Chemisorption, adsorption isotherms, Freundlich and Langmuir adsorption isotherm, BET equation, surface area determination, heterogeneous catalysis; colloids, electrical double layer and colloid stability, electro-kinetic phenomenon; elementary ideas about soaps & detergents, micelles, emulsions.

Electrochemistry:

Conductance: cell constant, specific conductance and molar conductance. Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility. Equivalent and molar conductance at infinite dilution. Ostwald's dilution law. Debye-Huckel theory. Application of conductance measurement. Conductometric titrations. Determination of transport number by moving boundary method. Types of electrochemical cells, cell reactions, emf and change in free energy, 6.H and AS of cell reactions. Nernst equation. Standard cells. Half-cells /electrodes, different types of electrodes. Standard electrode potential and principles of its determination. Types of concentration cells. Liquid junction potential. Glass electrode and determination of pH of a solution. Potentiometric titrations: acid-base and redox, electro chemical power sources; primary, secondary and fuel Cells, corrosion and inhibition of corrosion.

Photochemistry :

Frank-Condon principle and vibrational structure of electronic spectra. Bond dissociation and principle of determination of dissociation energy. Decay of excited states by radiative and non-radiative paths. Fluorescence and phosphorescence, Jablonsky diagram. Laws of photochemistry: Grotthus-Draper law, Stark-Einstein law of photochemical equivalence and Lambert-Beers law; quantum yield and its measurement for a photochemical process, actinometry. Photostationary state. Photosensitized reactions. Kinetics of HI decomposition, H2-Br2 reaction, dimerisation of anthracene.

Quantum Chemistry:

Wave-particle duality, Photoelectric and Compton effects, de Broglie hypothesis. Eigenfunctions and eigenvalues. Uncertainty relation, Expectation value. Hermitian operator. Schrodinger time-independent equation: nature of the equation, acceptability conditions imposed on the wave functions and probability interpretations of wave function. Schrodinger equation for one-dimensional box and its solution. Comparison with free particle eigenfunctions and eigenvalues.

Basic principles and application of spectroscopy:

Electromagnetic radiation, interaction with atoms and molecules and quantization of different forms of energies. Condition of resonance and energy of absorption for various types of spectra; origin of atomic spectra, spectra of hydrogen atoms, many electron atoms, spin and angular momentum. Rotational spectroscopy of diatomic molecules: rigid rotor model, selection rules, spectrum, characteristic features of spectral lines. Determination of bond length, effect of isotopic substitution. Vibrational spectroscopy of diatomic molecules: Simple Harmonic Oscillator model, selection rules, Raman Effect. Characteristic features and conditions of Raman activity with suitable illustrations. Rotational and vibrational Raman spectra.

UV Spectra: Electronic transition (a-a*, n-u*, IT-1T" and n-n'), relative positions of Amax considering conjugative effect, steric effect, solvent effect, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples). IR Spectra: Modes of molecular vibrations, application of Hooke's law, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=0 functions; factors effecting stretching frequencies

PMR Spectra: Nuclear spin, NMR active nuclei, principle of proton magnetic resonance, equivalent and non-equivalent protons, chemical shift ?), shielding / deshielding of protons, up-field and down-field shifts. NMR peak area, diamagnetic anisotropy, relative peak positions of different kinds of protons, substituted benzenes.

CHEMISTRY PAPER-III:200 Marks

PART-A (Analytical Chemistry): 100 Marks

Theoretical basis of Quantitative inorganic analysis:

Law of mass action, chemical and ionic equilibrium, solubility, Solubility product and common ion effect, effect of temperature upon the solubility of precipitates, the ionic product of water, pH, effect of temperature on pH, Salt hydrolysis, hydrolysis constant, degree of hydrolysis, buffer solutions, different types of buffers and Henderson's equation.

Gravimetric Analysis:

General principles, stoichiometry, calculation of results from gravimetric data. Properties of precipitates. Nucleation and crystal growth, factors influencing completion of precipitation. Co-precipitation and post-precipitation, purification and washing of precipitates. Precipitation from homogeneous solution, a few common gravimetric determinations-chloride as silver chloride, sulphate as barium sulphate, aluminum as the oxinate and nickel as dimethyl glyoximate.

Sampling and treatment of samples for chemical analysis:

Techniques of collection of Solids, liquids and gaseous samples, dissolution of solid samples, attack with water, acids, and alkalis, fusion with Na2CO3, NaOH, Na202, K2S207; Microwave assisted digestion techniques(Only elementary idea) **Volumetric Analysis:**

Equivalent weights, different types of solutions, Normal solutions, Molar solutions, and molal solutions and their inter relations. Primary and secondary standard substances. principles of different type of titrations-i) acid-base titration, ii) redox titration, iii) complexometric titrations. Types of indicators - i) acid-base, ii) redox iii) metal-ion indicators. Principles in estimation of mixtures of NaHCO3 and Na2CO3 (by acidimetry); Principles of estimation of iron, copper, manganese, chromium (by redox titration);

Acid base titrations: Principles of titrimetric analysis, titration curves for strong acid-strong base, weak acid-strong base and weak base-strong acid titrations, poly protic acids, poly equivalent bases, determining the equivalence point-theory of acid base indicators, colour change range of indicator, selection of proper indicator.

Redox Titrations: Principles behind the lodometry, permaganometry, dichrometry, difference between iodometry and iodimetry.

Potentiometry: Fundamentals of potentiometry. indicator and ion-selective electrodes. Membrane electrodes. Glass electrode for pH measurement, glass electrodes for cations other than protons. Liquid membrane electrodes, solid state ion selective detectors and biochemical electrodes. Applications of potentiometry. Direct potentiometric measurements-determination of pH and fluoride. Redox and potentiometer titrations- Balancing redox reactions, calculation of the equilibrium constant of the reaction, titration curves, visual end point detection. Redox indicators-theory, working and choice. Potentiometric end point detection. Applications of redox titrations.

Complexometric titrations: Complex formation reactions, stability of complexes, stepwise formation constants, chelating agents, EDTA-acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves, effect of other complexing agents, factors affecting the shape of titration curves-completeness of reaction, indicators for EDTA titrations-theory of common indicators, titration methods employing EDTA-direct, back and displacement titrations, indirect determinations, titration of mixtures, selectivity, masking and de-masking agents, typical

applications of EDTA titrations-hardness of water, magnesium and aluminium in antacids, magnesium, manganese and zinc in a mixture, titrations involving uni-dentate ligands-titration of chloride with Hg2+ and cyanide with Ag+.

Chromatographic methods of analysis:

Basic principles and classification of chromatography. Importance of column chromatography and thin layer chromatography; Theory and principles of High Performance Liquid Chromatography (HPLC) and Gas Liquid Chromatography (GLC). Ion-exchange chromatography.

UV-Visible Spectroscopy:

Basic Principles of UV-Vis spectrophotometer. Lambert -Beer's Law and its limitations. Instrumentation consisting of source, monochromator, grating and detector. Spectrophotometric determination.

Flame photometry and Atomic absorption spectrometry:

Emission spectra Vs absorption spectra. Basic Principles and theory of flame photometry. Applications of Flame photometers. Basic Principles and theory of AAS. Three different modes of AAS - Flame-MS, VGAAS, and GFAAS. Single beam and double beam AAS. Function of Halo Cathode Lamp (HCL) and Electrode Discharge Lamp (EDL). Different types of detectors used in MS. Different types of interferences-Matrix interferences, chemical interferences, Spectral interferences and background correction in AAS. Use of organic solvents. Quantitative techniques-calibration curve procedure and the standard addition technique. Typical commercial instruments for FP and MS. Applications. Qualitative and qualitative analysis. Relative detection abilities of atomic absorption and flame emission spectrometry.

X-ray methods of Analysis:

Introduction , theory of X-ray generation, X-ray spectroscopy, X-ray diffraction and X-ray fluorescence methods, Braggs law, instrumentation , dispersion by crystals, applications. Preparation of pallets, glass beads, quantitative and qualitative measurement.

Inductively coupled plasma spectroscopy:

Theory and Principles, plasma generation, utility of peristaltic pump, sampler - skimmer systems, ion lens, quadrupole mass analyzer, dynode /solid state Detector, different type of interferences- spectroscopic and non-spectroscopic interferences, isobaric and molecular interferences, applications.

Analysis of Minerals, Ores and Alloys:

Analysis of Minerals and Ores- estimation of (i) $CaCO_3$, $MgCO_3$ in dolomite (ii) Fe_2O_3, Al_2O_3, and TiO_2 in Bauxite.(iii) MnO and MnO_2 in Pyrolusite.

Analysis of Metal and Alloys: (i) Cu and Zn in Brass (ii) Cu, Zn, Fe, Mn, Al and Ni in Bronze (iii) Cr, Mn, Ni, and P in Steel (iv) Pb, Sb, Sn in type metal.

Analysis of petroleum and petroleum products:

Introduction, constituents and petroleum fractionation. Analysis of petroleum products-specific gravity, viscosity, Doctor test, aniline point, colour determination, cloud point, pour point. Determination of water, neutralization value (acid and base numbers), ash content, Determination of lead in petroleum.

Analysis of coal and coke-Types, composition, preparation of sample, proximate and ultimate anlaysis calorific value by bomb Calorimetry.

PART-B (Organic Chemistry): 100 Marks

Basic organic chemistry:

Inductive effect, resonance and resonance energy. Homolytic and heterolytic bond breaking, electrophiles and nucleophiles; carbocations, carbanions and radicals (stability and reactivity). Alkanes, alkenes and alkynes: Synthesis and chemical reactivity of alkanes, mechanism of free-radical halogenation of alkanes. General methods of synthesis, electrophilic addition reactions and polymerization reaction (definition and examples only) of alkenes. General methods of synthesis, acidity, hydration and substitution reactions of alkynes.

Organometallic compounds:

Grignard reagents - preparations and reactions, application of Grignard reagents in organic synthesis. Organic compounds containing nitrogen: aromatic nitro compounds - reduction under different conditions. Methods of synthesis of aliphatic amines, Heinsberg's method of amine separation, Hofmann degradation, Gabriel's phthalimide synthesis, distinction of primary, secondary and tertiary amines; methods of synthesis of aromatic amines, basicity of aliphatic and aromatic amines. Sandmeyer reactions; synthetic applications of benzene diazonium salts.

Bonding and physical properties:

Valence bond theory: concept of hybridisation, resonance (including hyperconjugation), orbital pictures of bonding sp3, sp2, sp: C-C, C-N & C-0 system). Inductive effect, bond polarization and bond polarizability, steric effect, steric inhibition of resonance. MO theory: sketch and energy levels of MOs of i) acyclic p orbital system ii) cyclic p orbital system, iii) neutral system. Frost diagram, Huckel's rules for aromaticity &

antiaromaticity; homoaromaticity. Physical properties: bond distance, bond angles, mp/bp & dipole moment in terms of structure and bonding. Heat of hydrogenation and heat of combustion.

Aldol and related reactions:

Keto-enol tautomerism, mechanism and synthetic applications of aldol condensations, Claisen reaction, Schmidt reaction, Perkin reaction, Knovenogal, benzoin, Cannizaro reaction, Michael addition. Aromatic substitution reactions - electrophilic, nucleophilic and through benzynes - radical substitution of arenes - orientation of nucleophilic substitution at a saturated, carbon, SN1, SN2, SNi reactions -effect of structure, nucleophile, leaving group, solvent. Additions involving electrophiles, nucleophiles and free radicals.

Mechanism of some name reactions:

Aldol, Perkin, Benzoin, Cannizaro, Wittig, Grignard, Reformatsky, Hoffmann, Claisen and Favorsky rearrangements. Openauer oxidation, clemmensen reduction, Meerwein - Pondorf and Verley and Birch reductions. Stork enamine reactions, Michael addition, Mannich Reaction, Diels - Alder reaction.

Electrocyclic Reactions:

Molecular orbital symmetry, frontier orbitals of ethylene, 1,3 Butadiene, 1,3,5- Hexatriene, ally! system, classfication of pericyclic reactions FMO approach, Woodwrd- Hoffman correlation diagram method and perturbation of molecular (PMO) approach for the explanation of pericyclic reactions under thermal and photochemical conditions. Conrotatory and disotatory motions (4n) and (4n+2).

Organic Reaction Mechanisms:

Addition Elimination Mechanisms: (a) Addition to carbon multiple bonds- hydrogenation of double and triple bonds, hydroboration, birch reduction, Michael reaction, addition of oxygen and N, (b) Addition to carbon-hetero atom multiple bonds: Mannich reaction,Reductions of Carbonyl compounds, acids, esters, nitrites, addtion of Grignard reagents, Reformatsky reaction, Tollen's reaction, Wittig reaction: (c) Elimination reactions: Stereochemistry of eliminations in acyclic and cyclic systems, orientation in eliminations - Saytzeff and Hoffman elimination.

Organic Spectroscopy:

Infrared spectroscopy: Units of frequency wave length and wave number, molecular vibrations, factors influencing vibrational frequencies, the IR spectrometer, characteristic frequencies of organic molecules and interpretation of spectra. Ultraviolet spectroscopy: Introduction, absorption laws, measurement of the spectrum, chromophores, definitions, applications of UV spectroscopy to Conjugated dines, trienes, unsaturated carbonyl compounds and aromatic compounds. Nuclear Magnetic Resonance Spectroscopy: (Proton and Carbon -13 NMR) The measurement of spectra, the chemical shift: the intensity of NMR signals and integration factors affecting the chemical shifts: spin-spin coupling to 13C IH-IH first order coupling: some simple IH-IH splitting patterns: the magnitude of IH-IH coupling constants.

Mass spectroscopy: Basic Principles: instrumentation: the mass spectrometer, isotope abundances; the molecular ion, meta stable ions.

HYDROGEOLOGY 200 Marks

Section A: Origin, occurrence and distribution of water.

Water on earth; Types of water — meteoric, juvenile, magmatic and sea water; Hydrological Cycle and its components; Water balance; Water-bearing properties of rocks — porosity, permeability, specific yield and specific retention; Vertical distribution of water; Zone of aeration and zone of saturation; Classification of rocks according to their water-bearing properties; Aquifers; Classification of aquifers; Concepts of drainage basins and groundwater basins; Aquifer parameters- transrnissivity and storage coefficient; Water table and piezometric surface; Fluctuations of water table and piezometric surface; Barometric and tidal efficiencies; Water table contour maps; Hydrographs; Springs; Geologic and geomorphic controls on groundwater; Hydrostratigraphic units;Groundwater provinces of India. Hydrogeology of arid zones of India;Hydrogeology of wet lands.

Section B: Groundwater Hydraulics

Theory of groundwater flow; Darcy's law and its applications; Determination of permeability in laboratory and in field; Flow through aquifers; steady, unsteady and radial flow conditions; Evaluation of aquifer parameters of confined, semi-confined and unconfined aquifers -Thiem, Thies, Jacob and Walton's methods; Groundwater modelling.

Section C: Groundwater Exploration and Water Well Construction

Geologic and hydrogeologic methods of exploration; Role of remote sensing in groundwater exploration; Hydrogeomorphic and lineament 'napping; Surface geophysical methods — seismic, gravity, geo-electrical and magnetic methods; Types of water wells and methods of construction; Design, development, maintenance and revitalization of wells; Sub-surface geophysical methods; Yield characteristics of wells; Pumping tests- methods, data analysis