

PART – 1 - PHYSICS**Electrostatics**

Frictional electricity, charges and their conservation; Coulomb's law-forces between two point electric charges - Forces between multiple electric charges-superposition principle.

Electric field – electric field due to a point charge, electric field lines; electric dipole, electric field intensity due to a dipole - behaviour of a dipole in a uniform electric field-application of electric dipole in microwave oven.

Electric potential - potential difference-electric potential due to a point charge and dipole-equipotential surfaces – electrical potential energy of a system of two point charges.

Electric flux-Gauss's theorem and its applications to find field due to (i) infinitely long straight wire (ii) uniformly charged infinite plane sheet (iii) two parallel sheets and (iv) uniformly charged thin spherical shell (inside and outside)

Electrostatic induction-capacitor and capacitance – dielectric and electric polarisation – parallel plate capacitor with and without dielectric medium – applications of capacitor – energy stored in a capacitor - Capacitors in series and in parallel – action of points – Lightning arrester – Van de Graaff generator.

Current Electricity

Electric Current – flow of charges in a metallic conductor – drift velocity and mobility and their relation with electric current.

Ohm's law, electrical resistance - V-I characteristics – electrical resistivity and conductivity-classification of materials in terms of conductivity – Superconductivity (elementary ideas) - Carbon resistors – colour code for carbon resistors - combination of resistors – series and parallel – temperature dependence of resistance – internal resistance of a cell – potential difference and emf of a cell - combinations of cells in series and in parallel.

Kirchoff's law – illustration by simple circuits – Wheatstone's Bridge and its application for temperature coefficient of resistance measurement - Metrebridge - special case of Wheatstone bridge - Potentiometer principle - comparing the emf of two cells.

Effects of Electric Current

Magnetic effect of electric current – Concept of magnetic field - Oersted's experiment – Biot-Savart law-Magnetic field due to an infinitely long current carrying straight wire and circular

coil – Tangent galvanometer – construction and working – Bar magnet as an equivalent solenoid – magnetic field lines.

Ampere's circuital law and its application.

Force on a moving charge in uniform magnetic field and electric field – cyclotron – Force on current carrying conductor in a uniform magnetic field – Forces between two parallel current carrying conductors - definition of ampere.

Torque experienced by a current loop in a uniform magnetic field - moving coil galvanometer – conversion to ammeter and voltmeter – current loop as a magnetic dipole and its magnetic dipole moment - Magnetic dipole moment of a revolving electron.

Electromagnetic Induction and Alternating Current

Electromagnetic induction - Faraday's law - induced emf and current - Lenz's law.

Self induction - Mutual induction - self inductance of a long solenoid - mutual inductance of two long solenoids.

Methods of inducing emf - (i) by changing magnetic induction (ii) by changing area enclosed by the coil and (iii) by changing the orientation of the coil (quantitative treatment).

AC generator - commercial generator. (Single phase, three phase).

Eddy current - applications - transformer - long distance transmission.

Alternating current - measurement of AC-AC circuit with resistance - AC circuit with inductor - AC circuit with capacitor - LCR series circuit - Resonance and Q - factor - power in AC circuits.

Electromagnetic Waves and Wave Optics

Electromagnetic waves and their characteristics - Electromagnetic spectrum-radio, microwaves, infra-red, visible, ultra-violet, X rays, gamma rays.

Wavefront and Huygens's principle - Reflection, total internal reflection and refraction of plane wave at a plane surface using wavefronts.

Interference - Young's double slit experiment and expression for fringe width - coherent source - interference of light- Formation of colours in thin films - analytical treatment - Newton's rings.

Diffraction - differences between interference and diffraction of light- diffraction grating.

Polarisation of light waves - polarisation by reflection - Brewster's law - double refraction - nicol prism - uses of plane polarised light and Polaroids - rotatory polarisation - polarimeter.

Atomic Physics

Atomic structure - discovery of the electron - specific charge (Thomson's method) and charge of the electron (Millikan's oil drop method) - alpha scattering - Rutherford's atom model.

Bohr's model - energy quantization - energy and wave number expressions - Hydrogen spectrum - energy level diagrams - sodium and mercury spectra - excitation and ionization potentials - Sommerfeld's atom model.

Masers and Lasers - spontaneous and stimulated emissions - normal population and population inversion - Ruby laser - He-Ne laser - properties and applications of laser light - holography.

Dual Nature of Radiation and Matter

Photoelectric effect - Light waves and photons - Einstein's photoelectric equation - laws of photoelectric emission - particle nature of energy - experimental verification of Einstein's photoelectric equation - work function - photo cells and their applications.

Matter waves - wave mechanical concept of the atom - wave nature of particles - de Broglie relation - de Broglie wavelength of an electron - electron microscope.

Nuclear Physics

Nuclear properties - nuclear radii, masses, binding energy, density, charge - isotopes, isobars and isotones - nuclear mass defect - binding energy - stability of nuclei - Bainbridge mass spectrometer.

Nature of nuclear forces - Neutron - discovery - properties - artificial transmutation - particle accelerator.

Radioactivity - alpha, beta and gamma radiations and their properties- α -decay, β -decay and γ -decay - Radioactive decay law - half life - mean life - artificial radioactivity - radio isotopes - effects and uses - Geiger - Muller counter.

Radio carbon dating - biological radiation hazards.

Nuclear fission - chain reaction - atom bomb - nuclear reactor - nuclear fusion - Hydrogen bomb - cosmic rays - elementary particles.

Semiconductor Devices and their Applications

Semiconductor theory - energy band in solids - difference between metals, insulators and semiconductors based on band theory - semiconductor doping - Intrinsic and Extrinsic semiconductors.

Formation of P-N Junction - Barrier potential and depletion layer-P-N Junction diode - Forward and reverse bias characteristics - diode as a rectifier - Zener diode-Zener diode as a voltage regulator - LED - seven segment display - LCD.

Junction transistors - characteristics - transistor as a switch - transistor as an amplifier - transistor biasing - RC, LC coupled and transformer coupling in amplifiers - feed back in amplifiers - positive and negative feedback - advantages of negative feedback in amplifiers - oscillator - condition for oscillations - LC circuit - Colpitt oscillator.

Logic gates - NOT, OR, AND, EXOR using discrete components - NAND and NOR gates as universal gates -Laws and theorems of Boolean algebra

PART – II - CHEMISTRY

Atomic Structure:

Bohr's atomic model-Sommerfeld's extension of atomic structure; Electronic configuration and Quantum numbers; Shapes of s,p,d,f orbitals - Pauli's exclusion principle - Hund's Rule of maximum multiplicity- Aufbau principle. Emission spectrum, absorption spectrum, line spectra and band spectra; Hydrogen spectrum - Lyman, Balmer, Paschen, Brackett and Pfund series; deBroglie's theory; Heisenberg's uncertainty principle - wave nature of electron - Schrodinger wave equation (No derivation). Eigen values and eigen functions. Hybridization of atomic orbitals involving s,p,d orbitals.

p,d and f – Block Elements:

p block elements - Phosphorous compounds; PCl_3 , PCl_5 - Oxides. Hydrogen halides, Inter halogen compounds. Xenon fluoride compounds. General Characteristics of d - block elements - Electronic Configuration - Oxidation states of first row transition elements and their colours; Occurrence and principles of extraction: Copper, Silver, Gold and Zinc. Preparation, properties of CuSO_4 , AgNO_3 and $\text{K}_2\text{Cr}_2\text{O}_7$.

Lanthanides - Introduction, electronic configuration, general characteristics, oxidation state - lanthanide contraction, uses, brief comparison of Lanthanides and Actinides.

Coordination Chemistry and Solid State Chemistry

Introduction - Terminology in coordination chemistry - IUPAC nomenclature of mononuclear coordination compounds. Isomerism, Geometrical isomerism in 4-coordinate, 6-coordinate complexes. Theories on coordination compounds - Werner's theory (brief), Valence Bond theory. Uses of

coordination compounds. Bioinorganic compounds (Haemoglobin and chlorophyll). Lattice - unit cell, systems, types of crystals, packing in solids; Ionic crystals - Imperfections in solids - point defects. X-Ray diffraction - Electrical Property, Amorphous solids (elementary ideas only).

Thermodynamics, Chemical Equilibrium and Chemical Kinetics

I and II law of thermodynamics - spontaneous and non spontaneous processes, entropy, Gibb's free energy - Free energy change and chemical equilibrium - significance of entropy. Law of mass action - Le Chatlier's principle, applications of chemical equilibrium. Rate expression, order and molecularity of reactions, zero order, first order and pseudo first order reaction - half life period. Determination of rate constant and order of reaction. Temperature dependence of rate constant - Arrhenius equation, activation energy.

Electrochemistry

Theory of electrical conductance; metallic and electrolytic conductance. Faraday's laws - theory of strong electrolytes - Specific resistance, specific conductance, equivalent and molar conductance - Variation of conductance with dilution - Kohlraush's law - Ionic product of water, p^H and p^{OH} - buffer solutions - use of p^H values. Cells - Electrodes and electrode potentials - construction of cell and EMF values, Fuel cells, Corrosion and its prevention.

Isomerism in Organic Compounds

Definition, Classification - structural isomerism, stereo isomerism - geometrical and optical isomerism. Optical activity - chirality - compounds containing chiral centres - R - S notation, D - L notation.

Alcohols and Ethers

Nomenclature of alcohols - Classification of alcohols - distinction between 1° , 2° and 3° alcohols - General methods of preparation of primary alcohols, properties. Methods of preparation of dihydric alcohols: Glycol - Properties - Uses. Methods of preparation of trihydric alcohols - Properties - Uses. Aromatic alcohols - preparation and properties of phenols and benzyl alcohol.

Ethers - Nomenclature of ethers - general methods of preparation of aliphatic ethers - Properties - Uses. Aromatic ethers - Preparation of Anisole - Uses.

Carbonyl Compounds

Nomenclature of carbonyl compounds - Comparison of aldehydes and ketones. General methods of preparation of aldehydes - Properties - Uses. Aromatic aldehydes - Preparation of benzaldehyde - Properties and Uses. Ketones - general methods of preparation of aliphatic ketones (acetone) - Properties - Uses. Aromatic ketones - preparation of

acetophenone - Properties - Uses, preparation of benzophenone - Properties. Name reactions; Clemmenson reduction, Wolff - Kishner reduction, Cannizaro reaction, Claisen Schmidt reaction, Benzoin Condensation, aldol Condensation. Preparation and applications of Grignard reagents.

Carboxylic Acids and their derivatives

Nomenclature - Preparation of aliphatic monobasic acids - formic acid - Properties - Uses. Monohydroxy mono carboxylic acids; Lactic acid - Synthesis of lactic acid. Aliphatic dicarboxylic acids; Preparation of oxalic and succinic acid. Aromatic acids; Benzoic and Salicylic acid - Properties - Uses. Derivatives of carboxylic acids; acetyl chloride (CH_3COCl) - Preparation - Properties - Uses. Preparation of acetamide, Properties - acetic anhydride - preparation, Properties. Preparation of esters - methyl acetate - Properties.

Organic Nitrogen Compounds

Aliphatic nitro compounds - Preparation of aliphatic nitroalkanes - Properties - Uses. Aromatic nitro compounds - Preparation - Properties - Uses. Distinction between aliphatic and aromatic nitro compounds. Amines; aliphatic amines - General methods of preparation - Properties - Distinction between 1° , 2° and 3° amines. Aromatic amines - Synthesis of benzylamine - Properties, Aniline - Preparation - Properties - Uses. Distinction between aliphatic and aromatic amine. Aliphatic nitriles - Preparation - properties - Uses. Diazonium salts - Preparation of benzene diazonium chloride - Properties.

Biomolecules

Carbohydrates - distinction between sugars and non sugars, structural formulae of glucose, fructose and sucrose, with their linkages, invert sugar - definition, examples of oligo and polysaccharides,

Amino acids - classification with examples, Peptides-properties of peptide bond,

Lipids - Definition, classification with examples, difference between fats, oils and waxes.

PART – III - MATHEMATICS

1. Applications of Matrices and Determinants

Adjoint, inverse - properties, computation of inverses, solution of system of linear equations by matrix inversion method.

Rank of a matrix - elementary transformation on a matrix, consistency of a system of linear equations, Cramer's rule, non-homogeneous equations, homogeneous linear system and rank method.

2. Complex Numbers

Complex number system - conjugate, properties, ordered pair representation.

Modulus – properties, geometrical representation, polar form, principal value, conjugate, sum, difference, product, quotient, vector interpretation, solutions of polynomial equations, De Moivre's theorem and its applications.

Roots of a complex number - n^{th} roots, cube roots, fourth roots.

3. Analytical Geometry of two dimensions

Definition of a conic – general equation of a conic, classification with respect to the general equation of a conic, classification of conics with respect to eccentricity.

Equations of conic sections (parabola, ellipse and hyperbola) in standard forms and general forms- Directrix, Focus and Latus rectum - parametric form of conics and chords. - Tangents and normals – cartesian form and parametric form- equation of chord of contact of tangents from a point (x_1, y_1) to all the above said curves.

Asymptotes, Rectangular hyperbola – Standard equation of a rectangular hyperbola.

4. Vector Algebra

Scalar Product – angle between two vectors, properties of scalar product, applications of dot products. vector product, right handed and left handed systems, properties of vector product, applications of cross product.

Product of three vectors – Scalar triple product, properties of scalar triple product, vector triple product, vector product of four vectors, scalar product of four vectors.

5. Analytical Geometry of Three Dimensions

Direction cosines – direction ratios - equation of a straight line passing through a given point and parallel to a given line, passing through two given points, angle between two lines.

Planes – equation of a plane, passing through a given point and perpendicular to a line, given the distance from the origin and unit normal, passing through a given point and parallel to two given lines, passing through two given points and parallel to a given line, passing through three given non-collinear points, passing through the line of intersection of two given planes, the distance between a point and a plane, the plane which contains two given lines (co-planar lines), angle between a line and a plane.

Skew lines - shortest distance between two lines, condition for two lines to intersect, point of intersection, collinearity of three points.

Sphere – equation of the sphere whose centre and radius are given, equation of a sphere when the extremities of the diameter are given.

6. Differential Calculus

Derivative as a rate measurer - rate of change, velocity, acceleration, related rates, derivative as a measure of slope, tangent, normal and angle between curves, maxima and minima.

Mean value theorem - Rolle's Theorem, Lagrange Mean Value Theorem, Taylor's and Maclaurin's series, L' Hospital's Rule, stationary points, increasing, decreasing, maxima, minima, concavity, convexity and points of inflexion.

Errors and approximations – absolute, relative, percentage errors - curve tracing, partial derivatives, Euler's theorem.

7. Integral Calculus and its Applications

Simple definite integrals – fundamental theorems of calculus, properties of definite integrals.

Reduction formulae – reduction formulae for $\int \sin^n x dx$ and $\int \cos^n x dx$, Bernoulli's formula.

Area of bounded regions, length of the curve.

8. Differential Equations

Differential equations - formation of differential equations, order and degree, solving differential equations (1st order), variables separable, homogeneous and linear equations.

Second order linear differential equations - second order linear differential equations with constant co-efficients, finding the particular integral if $f(x) = e^{mx}$, $\sin mx$, $\cos mx$, x , x^2 .

9. Probability Distributions

Probability – Axioms – Addition law - Conditional probability – Multiplicative law - Baye's Theorem - Random variable - probability density function, distribution function, mathematical expectation, variance

Theoretical distributions - discrete distributions, Binomial, Poisson distributions- Continuous distributions, Normal distribution.

10. Discrete Mathematics

Mathematical logic – logical statements, connectives, truth tables, logical equivalence, tautology, contradiction.

Groups-binary operations, semigroups, monoids, groups, order of a group, order of an element, properties of groups.

PART – IV - BIOLOGY

Taxonomy

Linnaean system of classification and Binomial nomenclature; history and types of classification; status of bacteria and viruses; classification of angiosperms up to sub-class level (Bentham and Hooker' systems); salient features of non-chordates up to phyla levels and chordates up to class levels.

Evolution

Modern concepts of organic evolution, evidences of organic evolution (Fossil records and biochemical evidences). Darwinism and neo – Darwinism, Lamarckism, Neo-Lamarckism, sources of variation, mutation, recombination, genetic drift, migration, natural selection. Origin and concepts of species: speciation and isolation (geographical pre-mating and post-mating or post zygotic), adaptive radiations; human evolution.

Cell and Molecular Biology

Discovery of cell, cell as a contained unit, pro and eukaryotic cells and its ultra structure. Cell division: amitosis, mitosis and meiosis. The cell: cell wall, cell membrane and cell organelles (Plastids, mitochondria, endoplasmic reticulum, Golgi bodies, ribosomes, lysosomes, vacuoles and centrioles)

DNA and RNA, DNA as genetic material, RNA as genetic material, replication, transcription, genetic code, translation splicing, gene expression and regulation, protein synthesis, DNA repair.

Reproduction

Reproduction in Plants: asexual and sexual reproduction, vegetative propagation, sexual reproduction in flowering plants, structure of flowers, pollination, fertilization, development of seeds and fruits, apomixes and poly-embryony

Human reproduction and Reproductive health: reproductive system in male and female, menstrual cycles, production of gametes, fertilization, implantation, embryo development, pregnancy, parturition and lactation, Assisted reproductive technologies.

Genetics

Chromosomes: structure and types, linkage and crossing over, recombination of chromosomes, mutation, chromosomal aberration, Mendelian inheritance, chromosomal theory of inheritance, deviation from Mendelian ratio (gene interaction, incomplete dominance, co-dominance, complimentary gene, multiple allelism), sex determination in humans, chromosomal disorders in humans.

Microbiology and Immunology

Introduction to microbial diversity, history of medical microbiology, discovery of antibiotics, pasteurization, microscopes. Fungi, bacteria, virus, protozoa, algae –

beneficial and harmful. Parasites and pathogens. Structure of microbes and diseases caused by them. Basic concepts of immunology: Innate and humoral immunity, lymphoid organs, lymph nodes and spleen, antibodies, vaccines, transplantation immunology, immune system disorders.

Biochemistry

Structure and function of carbohydrates, lipids, proteins. Disaccharide, starch, glycogen, fats, cholesterol, amino acids, peptides. Primary, Secondary and Tertiary structure of proteins. Enzymes, structure and mechanism of enzyme catalysis, specificity of enzymes, co factors and co-enzymes.

Physiology: Plant and Human

Plant Physiology: Movement of water, food, nutrients, gases and minerals. Respiration, photosynthesis (light and dark reactions), Factors affecting photosynthesis, electron transport chain (ETC), glycolysis, Krebs' cycle, pentose phosphate pathway, hormones and growth regulators, Photo-periodism and vernalization.

Human Physiology: Digestion and absorption, breathing and respiration, body fluids and circulation, excretory system, endocrine system, nervous system, skeletal and muscular systems: locomotion and movement, growth, aging and death. Hormones; types of hormones and its functions.

Biotechnology and its applications

Recombinant DNA technology, applications in health, agriculture and industries; genetically modified organisms; bio-safety issues, insulin and Bt cotton, transgenic plants and microbes, plant tissue culture and its application; plant growth regulators; Microbes in food processing; industrial production of microbial products, Sewage treatment, waste management and energy generation.

Biodiversity, ecology and environment

Ecosystems: components, types and energy flow in ecosystem; species, population and community, ecological adaptations, centers of diversity and conservation of bio-diversity, Red data book, botanical gardens, national parks, sanctuaries and museums, environmental issues, human population explosion, green house effects, ozone layer depletion, Environmental issues and Pollution control.

Applied biology and human welfare

Bio-pesticides, genetically modified foods, bio-war, bio-piracy, bio-pattern, sustainable agriculture and medicinal plants, economic important plants (food crops, oil seeds, fiber yielding, sugar crops and timber yielding), bio-pharming, pesticides, organic agriculture. Population and birth control, contraception and MTP, sexually transmitted diseases, infertility, cancer and AIDS. Adolescence and drug/or alcohol abuse.