

# Syllabus for BITSAT-2021

## Part I: Physics

### 1. Units & Measurement

Units (Different systems of units, SI units, fundamental and derived units)

Dimensional Analysis

Precision and significant figures

Fundamental measurements in Physics (Vernier calipers, screw gauge, Physical balance etc)

### 2. Kinematics

Properties of vectors

Position, velocity and acceleration vectors

Motion with constant acceleration

Projectile motion

Uniform circular motion

Relative motion

### 3. Newton's Laws of Motion

Newton's laws (free body diagram, resolution of forces)

Motion on an inclined plane

Motion of blocks with pulley systems

Circular motion – centripetal force

Inertial and non-inertial frames

### 4. Impulse and Momentum

Definition of impulse and momentum

Conservation of momentum

Collisions

Momentum of a system of particles

Center of mass

### 5. Work and Energy

Work done by a force

Kinetic energy and work-energy theorem

Power

Conservative forces and potential energy

Conservation of mechanical energy

### 6. Rotational Motion

Description of rotation (angular displacement, angular velocity and angular acceleration)

Rotational motion with constant angular acceleration

Moment of inertia, Parallel and perpendicular axes theorems, rotational kinetic energy

Torque and angular momentum

Conservation of angular momentum

Rolling motion

## 7. Gravitation

Newton's law of gravitation  
Gravitational potential energy, Escape velocity  
Motion of planets – Kepler's laws, satellite motion

## 8. Mechanics of Solids and Fluids

Elasticity  
Pressure, density and Archimedes' principle  
Viscosity and Surface Tension  
Bernoulli's theorem

## 9. Oscillations

Kinematics of simple harmonic motion  
Spring mass system, simple and compound pendulum  
Forced & damped oscillations, resonance

## 10. Waves

Progressive sinusoidal waves  
Standing waves in strings and pipes  
Superposition of waves, beats  
Doppler Effect

## 11. Heat and Thermodynamics

Kinetic theory of gases  
Thermal equilibrium and temperature  
Specific heat, Heat Transfer - Conduction, convection and radiation, thermal conductivity, Newton's law of cooling Work, heat and first law of thermodynamics  
2<sup>nd</sup> law of thermodynamics, Carnot engine – Efficiency and Coefficient of performance

## 12. Electrostatics

Coulomb's law  
Electric field (discrete and continuous charge distributions)  
Electrostatic potential and Electrostatic potential energy  
Gauss' law and its applications  
Electric dipole  
Capacitance and dielectrics (parallel plate capacitor, capacitors in series and parallel)

## 13. Current Electricity

Ohm's law, Joule heating  
D.C circuits – Resistors and cells in series and parallel, Kirchoff's laws, potentiometer and Wheatstone bridge  
Electrical Resistance (Resistivity, origin and temperature dependence of resistivity).

## 14. Magnetic Effect of Current

Biot-Savart's law and its applications  
Ampere's law and its applications  
Lorentz force, force on current carrying conductors in a magnetic field  
Magnetic moment of a current loop, torque on a current loop, Galvanometer and its conversion to voltmeter and ammeter

## 15. Electromagnetic Induction

Faraday's law, Lenz's law, eddy currents  
Self and mutual inductance  
Transformers and generators  
Alternating current (peak and rms value)  
AC circuits, LCR circuits

## 16. Optics

Laws of reflection and refraction  
Lenses and mirrors  
Optical instruments – telescope and microscope  
Interference – Huygen's principle, Young's double slit experiment  
Interference in thin films  
Diffraction due to a single slit  
Electromagnetic waves and their characteristics (only qualitative ideas), Electromagnetic spectrum  
Polarization – states of polarization, Malus' law, Brewster's law

## 17. Modern Physics

Dual nature of light and matter – Photoelectric effect, De Broglie wavelength  
Atomic models – Rutherford's experiment, Bohr's atomic model  
Hydrogen atom spectrum  
Radioactivity  
Nuclear reactions : Fission and fusion, binding energy

## 18. Electronic Devices

Energy bands in solids (qualitative ideas only), conductors, insulators and semiconductors;  
Semiconductor diode –  $I$ - $V$  characteristics in forward and reverse bias, diode as a rectifier;  $I$ - $V$  characteristics of LED, photodiode, solar cell, and Zener diode; Zener diode as a voltage regulator.  
Junction transistor, transistor action, characteristics of a transistor; transistor as an amplifier (common emitter configuration) and oscillator  
Logic gates (OR, AND, NOT, NAND and NOR). Transistor as a switch.

# Part II: Chemistry

## 1. States of Matter

Measurement: Physical quantities and SI units, Dimensional analysis, Precision, Significant figures.

Chemical reactions: Laws of chemical combination, Dalton's atomic theory; Mole concept; Atomic, molecular and molar masses; Percentage composition empirical & molecular formula; Balanced chemical equations & stoichiometry

Three states of matter, intermolecular interactions, types of bonding, melting and boiling points  
Gaseous state: Gas Laws, ideal behavior, ideal gas equation, empirical derivation of gas equation, Avogadro number, Deviation from ideal behaviour – Critical temperature, Liquefaction of gases, van der Waals equation.

Liquid state: Vapour pressure, surface tension, viscosity.

Solid state: Classification; Space lattices & crystal systems; Unit cell in two dimensional and three dimensional lattices, calculation of density of unit cell – Cubic & hexagonal systems; Close packing; Crystal structures: Simple AB and AB<sub>2</sub> type ionic crystals, covalent crystals – diamond & graphite, metals. Voids, number of atoms per unit cell in a cubic unit cell, Imperfections- Point

defects, non-stoichiometric crystals; Electrical, magnetic and dielectric properties; Amorphous solids – qualitative description. Band theory of metals, conductors, semiconductors and insulators, and n- and p- type semiconductors.

## 2. Atomic Structure

Introduction: Subatomic particles; Atomic number, isotopes and isobars, Thompson's model and its limitations, Rutherford's picture of atom and its limitations; Hydrogen atom spectrum and Bohr model and its limitations.

Quantum mechanics: Wave-particle duality – de Broglie relation, Uncertainty principle; Hydrogen atom: Quantum numbers and wavefunctions, atomic orbitals and their shapes (s, p, and d), Spin quantum number.

Many electron atoms: Pauli exclusion principle; Aufbau principle and the electronic configuration of atoms, Hund's rule.

3. Periodicity: Brief history of the development of periodic tables Periodic law and the modern periodic table; Types of elements: s, p, d, and f blocks; Periodic trends: ionization energy, atomic, and ionic radii, inter gas radii, electron affinity, electro negativity and valency. Nomenclature of elements with atomic number greater than 100.

### Chemical Bonding & Molecular Structure

Valence electrons, Ionic Bond: Lattice Energy and Born-Haber cycle; Covalent character of ionic bonds and polar character of covalent bond, bond parameters

Molecular Structure: Lewis picture & resonance structures, VSEPR model & molecular shapes

Covalent Bond: Valence Bond Theory- Orbital overlap, Directionality of bonds & hybridization (s, p & d orbitals only), Resonance; Molecular orbital theory- Methodology, Orbital energy level diagram, Bond order, Magnetic properties for homonuclear diatomic species (qualitative idea only).

Dipole moments; Hydrogen Bond.

## 4. Thermodynamics

Basic Concepts: Systems and surroundings; State functions; Intensive & Extensive Properties; Zeroth Law and Temperature

First Law of Thermodynamics: Work, internal energy, heat, enthalpy, heat capacities and specific heats, measurements of  $\Delta U$  and  $\Delta H$ , Enthalpies of formation, phase transformation, ionization, electron gain; Thermochemistry; Hess's Law, Enthalpy of bond dissociation, combustion, atomization, sublimation, solution and dilution

Second Law: Spontaneous and reversible processes; entropy; Gibbs free energy related to spontaneity and non-spontaneity, non-mechanical work; Standard free energies of formation, free energy change and chemical equilibrium

Third Law: Introduction

## 5. Physical and Chemical Equilibria

Concentration Units: Mole Fraction, Molarity, and Molality

Solutions: Solubility of solids and gases in liquids, Vapour Pressure, Raoult's law, Relative lowering of vapor pressure, depression in freezing point; elevation in boiling point; osmotic pressure, determination of molecular mass; solid solutions, abnormal molecular mass, van't Hoff factor. Equilibrium: Dynamic nature of equilibrium, law of mass action

Physical Equilibrium: Equilibria involving physical changes (solid-liquid, liquid-gas, solid-gas), Surface chemistry, Adsorption, Physical and Chemical adsorption, Langmuir Isotherm, Colloids and emulsion, classification, preparation, uses.

Chemical Equilibria: Equilibrium constants ( $K_p$ ,  $K_c$ ), Factors affecting equilibrium, Le- Chatelier's principle.

Ionic Equilibria: Strong and Weak electrolytes, Acids and Bases (Arrhenius, Lewis, Lowry and Bronsted) and their dissociation; degree of ionization, Ionization of Water; ionization of polybasic acids, pH; Buffer solutions; Henderson equation, Acid-base titrations; Hydrolysis; Solubility Product of Sparingly Soluble Salts; Common Ion Effect.

Factors Affecting Equilibria: Concentration, Temperature, Pressure, Catalysts, Significance of  $\Delta G$  and  $G^0$  in Chemical Equilibria.

## 6. Electrochemistry

Redox Reactions: Oxidation-reduction reactions (electron transfer concept); Oxidation number; Balancing of redox reactions; Electrochemical cells and cell reactions; Standard electrode potentials; EMF of Galvanic cells; Nernst equation; Factors affecting the electrode potential; Gibbs energy change and cell potential; Secondary cells; dry cells, Fuel cells; Corrosion and its

prevention.

Electrolytic Conduction: Electrolytic Conductance; Specific and molar conductivities; variations of conductivity with concentration, Kohlrausch's Law and its application, Electrolysis, Faraday's laws of electrolysis; Electrode potential and electrolysis, Commercial production of the chemicals, NaOH, Na, Al.

## 7. Chemical Kinetics

Aspects of Kinetics: Rate and Rate expression of a reaction; Rate constant; Order and molecularity of the reaction; Integrated rate expressions and half-life for zero and first order reactions.

Factor Affecting the Rate of the Reactions: Concentration of the reactants, catalyst; size of particles, Temperature dependence of rate constant concept of collision theory (elementary idea, no mathematical treatment); Activation energy.

**Surface Chemistry:** Adsorption – physisorption and chemisorption; factors affecting adsorption of gasses on solids; catalysis: homogeneous and heterogeneous, activity and selectivity: enzyme catalysis, colloidal state: distinction between true solutions, colloids and suspensions; lyophilic, lyophobic multi molecular and macromolecular colloids; properties of colloids; Tyndall effect, Brownian movement, electrophoresis, coagulations; emulsions–types of emulsions.

## 8. Hydrogen and s-block elements

Hydrogen: Element: unique position in periodic table, occurrence, isotopes; Dihydrogen: preparation, properties, reactions, and uses; Molecular, saline, ionic, covalent, interstitial hydrides; Water: Properties; Structure and aggregation of water molecules; Heavy water; Hydrogen peroxide: preparation, reaction, structure & use, Hydrogen as a fuel.

s-block elements: Abundance and occurrence; Anomalous properties of the first elements in each group; diagonal relationships; trends in the variation of properties (ionization energy, atomic & ionic radii).

Alkali metals: Lithium, sodium and potassium: occurrence, extraction, reactivity, and electrode potentials; Biological importance; Reactions with oxygen, hydrogen, halogens water; Basic nature of oxides and hydroxides; Halides; Properties and uses of compounds such as NaCl, Na<sub>2</sub>CO<sub>3</sub>, NaHCO<sub>3</sub>, NaOH, KCl, and KOH.

Alkaline earth metals: Magnesium and calcium: Occurrence, extraction, reactivity and electrode potentials; Reactions with O<sub>2</sub>, H<sub>2</sub>O, H<sub>2</sub> and halogens; Solubility and thermal stability of oxo salts; Biological importance of Ca and Mg; Preparation, properties and uses of important compounds such as CaO, Ca(OH)<sub>2</sub>, plaster of Paris, MgSO<sub>4</sub>, MgCl<sub>2</sub>, CaCO<sub>3</sub>, and CaSO<sub>4</sub>.

## 9. p- d- and f-block elements

General: Abundance, distribution, physical and chemical properties, isolation and uses of elements; Trends in chemical reactivity of elements of a group; electronic configuration, oxidation states; anomalous properties of first element of each group.

Group 13 elements: Boron; Properties and uses of borax, boric acid, boron hydrides & halides. Reaction of aluminum with acids and alkalis;

Group 14 elements: Carbon: carbon catenation, physical & chemical properties, uses, allotropes (graphite, diamond, fullerenes), oxides, halides and sulphides, carbides; Silicon: Silica, silicates, silicone, silicon tetrachloride, Zeolites, and their uses

Group 15 elements: Dinitrogen; Preparation, reactivity and uses of nitrogen; Industrial and biological nitrogen fixation; Compound of nitrogen; Ammonia: Haber's process, properties and reactions; Oxides of nitrogen and their structures; Properties and Ostwald's process of nitric acid production; Fertilizers – NPK type; Production of phosphorus; Allotropes of phosphorus; Preparation, structure and properties of hydrides, oxides, oxoacids (elementary idea only) and halides of phosphorus, phosphine.

Group 16 elements: Isolation and chemical reactivity of dioxygen; Acidic, basic and amphoteric oxides; Preparation, structure and properties of ozone; Allotropes of sulphur; Preparation/production properties and uses of sulphur dioxide and sulphuric acid; Structure and properties of oxides, oxoacids (structures only).

Group 17 and group 18 elements: Structure and properties of hydrides, oxides, oxoacids of halogens (structures only); preparation, properties & uses of chlorine & HCl; Inter halogen compounds; Bleaching Powder; Uses of Group 18 elements, Preparation, structure and reactions of xenon fluorides, oxides, and oxoacids.

d-Block elements: General trends in the chemistry of first row transition elements; Metallic character; Oxidation state; ionization enthalpy; Ionic radii; Color; Catalytic properties; Magnetic

properties; Interstitial compounds; Occurrence and extraction of iron, copper, silver, zinc, and mercury; Alloy formation; Steel and some important alloys; preparation and properties of  $K_2Cr_2O_7$ ,  $KMnO_4$ .

f-Block elements: Lanthanoids and actinoids; Oxidation states and chemical reactivity of lanthanoids compounds; Lanthanide contraction and its consequences, Comparison of actinoids and lanthanoids.

Coordination Compounds: Coordination number; Ligands; Werner's coordination theory; IUPAC nomenclature; Application and importance of coordination compounds (in qualitative analysis, extraction of metals and biological systems e.g. chlorophyll, vitamin B12, and hemoglobin); Bonding: Valence-bond approach, Crystal field theory (qualitative); Isomerism including stereoisomerisms.

## 10. Principles of Organic Chemistry and Hydrocarbons

Classification: General Introduction, classification based on functional groups, trivial and IUPAC nomenclature. Methods of purification: qualitative and quantitative,

Electronic displacement in a covalent bond: Inductive, resonance effects, and hyperconjugation; free radicals; carbocations, carbanions, nucleophiles and electrophiles; types of organic reactions, free radical halogenations.

Alkanes: Structural isomerism, general properties and chemical reactions, free radical halogenation, combustion and pyrolysis.

Alkenes and alkynes: General methods of preparation and reactions, physical properties, electrophilic and free radical additions, acidic character of alkynes and (1,2 and 1,4) addition to dienes.

Aromatic hydrocarbons: Sources; properties; isomerism; resonance delocalization; aromaticity; polynuclear hydrocarbons; IUPAC nomenclature; mechanism of electrophilic substitution reaction, directive influence and effect of substituents on reactivity; carcinogenicity and toxicity.

Haloalkanes and haloarenes: Physical properties, nomenclature, optical rotation, chemical reactions and mechanism of substitution reaction. Uses and environmental effects; di, tri, tetrachloromethanes, iodoform, freon and DDT.

## 11. Stereochemistry

Conformations: Ethane conformations; Newman and Sawhorse projections.

Geometrical isomerism in alkenes

## 12. Organic Compounds with Functional Groups Containing Oxygen and Nitrogen

General: Nomenclature, electronic structure, important methods of preparation, identification, important reactions, physical and chemical properties, uses of alcohols, phenols, ethers, aldehydes, ketones, carboxylic acids, nitro compounds, amines, diazonium salts, cyanides and isocyanides.

Specific: Reactivity of  $\alpha$ -hydrogen in carbonyl compounds, effect of substituents on  $\alpha$ -carbon on acid strength, comparative reactivity of acid derivatives, mechanism of nucleophilic addition and dehydration, basic character of amines, methods of preparation, and their separation, importance of diazonium salts in synthetic organic chemistry.

## 13. Biological, Industrial and Environmental chemistry

Carbohydrates: Classification; Monosaccharides; Structures of pentoses and hexoses; Simple chemical reactions of glucose, Disaccharides: reducing and non-reducing sugars – sucrose, maltose and lactose; Polysaccharides: elementary idea of structures of starch, cellulose and glycogen.

Proteins: Amino acids; Peptide bond; Polypeptides; Primary structure of proteins; Simple idea of secondary, tertiary and quaternary structures of proteins; Denaturation of proteins and enzymes.

Nucleic Acids: Types of nucleic acids; Primary building blocks of nucleic acids (chemical composition of DNA & RNA); Primary structure of DNA and its double helix; Replication; Transcription and protein synthesis; Genetic code.

Vitamins: Classification, structure, functions in biosystems; Hormones

Polymers: Classification of polymers; General methods of polymerization; Molecular mass of polymers; Biopolymers and biodegradable polymers; methods of polymerization (free radical, cationic and anionic addition polymerizations); Copolymerization: Natural rubber; Vulcanization

of rubber; Synthetic rubbers. Condensation polymers.

Pollution: Environmental pollutants; soil, water and air pollution; Chemical reactions in atmosphere; Smog; Major atmospheric pollutants; Acid rain; Ozone and its reactions; Depletion of ozone layer and its effects; Industrial air pollution; Green house effect and global warming; Green Chemistry, study for control of environmental pollution.

Chemicals in medicine, health-care and food: Analgesics, Tranquilizers, antiseptics, disinfectants, anti-microbials, anti-fertility drugs, antihistamines, antibiotics, antacids; Preservatives, artificial sweetening agents, antioxidants, soaps and detergents.

#### 14. Theoretical Principles of Experimental Chemistry

Volumetric Analysis: Principles; Standard solutions of sodium carbonate and oxalic acid; Acid-base titrations; Redox reactions involving KI, H<sub>2</sub>SO<sub>4</sub>, Na<sub>2</sub>SO<sub>3</sub>, Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and H<sub>2</sub>S; Potassium permanganate in acidic, basic and neutral media; Titrations of oxalic acid, ferrous ammonium sulphate with KMnO<sub>4</sub>, K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>/Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>, Cu(II)/Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>.

Qualitative analysis of Inorganic Salts: Principles in the determination of the cations Pb<sup>2+</sup>, Cu<sup>2+</sup>, As<sup>3+</sup>, Mn<sup>2+</sup>, Al<sup>3+</sup>, Zn<sup>2+</sup>, Co<sup>2+</sup>, Ca<sup>2+</sup>, Sr<sup>2+</sup>, Ba<sup>2+</sup>, Mg<sup>2+</sup>, NH<sub>4</sub><sup>+</sup>, Fe<sup>3+</sup>, Ni<sup>2+</sup> and the anions CO<sub>3</sub><sup>2-</sup>, S<sup>2-</sup>, SO<sub>4</sub><sup>2-</sup>, SO<sub>3</sub><sup>2-</sup>, NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>, Br<sup>-</sup>, I<sup>-</sup>, PO<sub>4</sub><sup>3-</sup>, CH<sub>3</sub>COO<sup>-</sup>, C<sub>2</sub>O<sub>4</sub><sup>2-</sup>.

Physical Chemistry Experiments: preparation and crystallization of alum, copper sulphate. Benzoic acid ferrous sulphate, double salt of alum and ferrous sulphate, potassium ferric sulphate; Temperature vs. solubility; Study of pH changes by common ion effect in case of weak acids and weak bases; pH measurements of some solutions obtained from fruit juices, solutions of known and varied concentrations of acids, bases and salts using pH paper or universal indicator; Lyophilic and lyophobic sols; Dialysis; Role of emulsifying agents in emulsification. Equilibrium studies involving ferric and thiocyanate ions (ii) [Co(H<sub>2</sub>O)<sub>6</sub>]<sup>2+</sup> and chloride ions; Enthalpy determination for strong acid vs. strong base neutralization reaction (ii) hydrogen bonding interaction between acetone and chloroform; Rates of the reaction between (i) sodium thiosulphate and hydrochloric acid, (ii) potassium iodate and sodium sulphite (iii) iodide vs. hydrogen peroxide, concentration and temperature effects in these reactions.

Purification Methods: Filtration, crystallization, sublimation, distillation, differential extraction, and chromatography. Principles of melting point and boiling point determination; principles of paper chromatographic separation – R<sub>f</sub> values.

Qualitative Analysis of Organic Compounds: Detection of nitrogen, sulphur, phosphorous and halogens; Detection of carbohydrates, fats and proteins in foodstuff; Detection of alcoholic, phenolic, aldehydic, ketonic, carboxylic, amino groups and unsaturation.

Quantitative Analysis of Organic Compounds: Basic principles for the quantitative estimation of carbon, hydrogen, nitrogen, halogen, sulphur and phosphorous; Molecular mass determination by silver salt and chloroplatinate salt methods; Calculations of empirical and molecular formulae.

Principles of Organic Chemistry Experiments: Preparation of iodoform, acetanilide, p-nitro acetanilide, di-benzoyl acetone, aniline yellow, beta-naphthol; Preparation of acetylene and study of its acidic character.

Basic Laboratory Technique: Cutting glass tube and glass rod, bending a glass tube, drawing out a glass jet, boring of cork.

## Part III: (a) English Proficiency and (b) Logical Reasoning

### (a) English Proficiency

This test is designed to assess the test takers' general proficiency in the use of English language as a means of self-expression in real life situations and specifically to test the test takers' knowledge of basic grammar, their vocabulary, their ability to read fast and comprehend, and also their ability to apply the elements of effective writing.

#### 1. Grammar

Agreement, Time and Tense, Parallel construction, Relative pronouns  
Determiners, Prepositions, Modals, Adjectives

Voice, Transformation

Question tags, Phrasal verbs

## 2. Vocabulary

Synonyms, Antonyms, Odd Word, One Word, Jumbled letters, Homophones, Spelling

Contextual meaning.

Analogy

## 3. Reading Comprehension

Content/ideas

Vocabulary

Referents

Idioms/Phrases

Reconstruction (rewording)

## 4. Composition

Rearrangement

Paragraph Unity

Linkers/Connectives

### **(b) Logical Reasoning**

The test is given to the candidates to judge their power of reasoning spread in verbal and nonverbal areas. The candidates should be able to think logically so that they perceive the data accurately, understand the relationships correctly, figure out the missing numbers or words, and to apply rules to new and different contexts. These indicators are measured through performance on such tasks as detecting missing links, following directions, classifying words, establishing sequences, and completing analogies.

## 5. Verbal Reasoning

**Analogy:** Analogy means correspondence. In the questions based on analogy, a particular relationship is given and another similar relationship has to be identified from the alternatives provided.

**Classification:** Classification means to assort the items of a given group on the basis of certain common quality they possess and then spot the odd option out.

**Series Completion:** Here series of numbers or letters are given and one is asked to either complete the series or find out the wrong part in the series.

**Logical Deduction:** Reading Passage: Here a brief passage is given and based on the passage the candidate is required to identify the correct or incorrect logical conclusions.

**Chart Logic:** Here a chart or a table is given that is partially filled in and asks to complete it in accordance with the information given either in the chart / table or in the question.

## 6. Nonverbal Reasoning

**Pattern Perception:** Here a certain pattern is given and generally a quarter is left blank. The candidate is required to identify the correct quarter from the given four alternatives.

**Figure Formation and Analysis:** The candidate is required to analyze and form a figure from various given parts.

**Paper Cutting:** It involves the analysis of a pattern that is formed when a folded piece of paper is cut into a definite design.

**Figure Matrix:** In this more than one set of figures is given in the form of a matrix, all of them following the same rule. The candidate is required to follow the rule and identify the missing figure.

**Rule Detection:** Here a particular rule is given and it is required to select from the given sets of figures, a set of figures, which obeys the rule and forms the correct series.

## Part IV: Mathematics

## 1. Algebra

Complex numbers, addition, multiplication, conjugation, polar representation, properties of modulus and principal argument, triangle inequality, roots of complex numbers, geometric interpretations; Fundamental theorem of algebra.

Theory of Quadratic equations, quadratic equations in real and complex number system and their solutions.

Arithmetic and geometric progressions, arithmetic, geometric and arithmetico• geometric series, sums of finite arithmetic and geometric progressions, infinite geometric series, sums of squares and cubes of the first  $n$  natural numbers.

Logarithms and their properties.

Exponential series.

Permutations and combinations, Permutations as an arrangement and combination as selection, simple applications.

Binomial theorem for a positive integral index, properties of binomial coefficients, Pascal's triangle

Matrices and determinants of order two or three, properties and evaluation of determinants, addition and multiplication of matrices, adjoint and inverse of matrices, Solutions of simultaneous linear equations in two or three variables, elementary row and column operations of matrices, Types of matrices, applications of determinants in finding the area of triangles.

Sets, Relations and Functions, algebra of sets applications, equivalence relations, mappings, one•one, into and onto mappings, composition of mappings, binary operation, inverse of function, functions of real variables like polynomial, modulus, signum and greatest integer.

Mathematical reasoning and methods of proofs, Mathematically acceptable statements. Connecting words/phrases – consolidating the understanding of “if and only if (necessary and sufficient) condition”, “implies”, “and/or”, “implied” by”, “and”, “or”, “there exists” and through variety of examples related to real life and Mathematics. Validating the statements involving the connecting words – difference between contradiction, converse and contra positive., Mathematical induction

Linear Inequalities, solution of linear inequalities in one variable (Algebraic) and two variables (Graphical).

## 2. Trigonometry

Measurement of angles in radians and degrees, positive and negative angles, trigonometric ratios, functions with their graphs and identities.

Solution of trigonometric equations.

Inverse trigonometric functions

## 3. Two-dimensional Coordinate Geometry

Cartesian coordinates, distance between two points, section formulae, shift of origin.

Straight lines and pair of straight lines: Equation of straight lines in various forms, angle between two lines, distance of a point from a line, lines through the point of intersection of two given lines, equation of the bisector of the angle between two lines, concurrent lines.

Circles: Equation of circle in standard form, parametric equations of a circle.

Conic sections: parabola, ellipse and hyperbola their eccentricity, directrices & foci.

## 4. Three dimensional Coordinate Geometry

Co-ordinate axes and co-ordinate planes, distance between two points, section formula, direction cosines and direction ratios, equation of a straight line in space and skew lines.

Angle between two lines whose direction ratios are given, shortest distance between two lines.

Equation of a plane, distance of a point from a plane, condition for coplanarity of three lines, angles between two planes, angle between a line and a plane.

## 5. Differential calculus

Domain and range of a real valued function, Limits and Continuity of the sum, difference, product and quotient of two functions, Differentiability.

Derivative of different types of functions (polynomial, rational, trigonometric, inverse trigonometric, exponential, logarithmic, implicit functions), derivative of the sum, difference, product and quotient of two functions, chain rule, parametric form.

Geometric interpretation of derivative, Tangents and Normal.

Increasing and decreasing functions, Maxima and minima of a function.

Rolle's Theorem, Mean Value Theorem and Intermediate Value Theorem.

## 6. Integral calculus

Integration as the inverse process of differentiation, indefinite integrals of standard functions.

Methods of integration: Integration by substitution, Integration by parts, integration by partial fractions, and integration by trigonometric identities.

Definite integrals and their properties, Fundamental Theorem of Integral Calculus, applications in finding areas under simple curves.

Application of definite integrals to the determination of areas of regions bounded by simple curves.

## 7. Ordinary Differential Equations

Order and degree of a differential equation, formulation of a differential equation whole general solution is given, variables separable method.

Solution of homogeneous differential equations of first order and first degree

Linear first order differential equations

## 8. Probability

Various terminology in probability, axiomatic and other approaches of probability, addition and multiplication rules of probability.

Conditional probability, total probability and Baye's theorem

Independent events

Discrete random variables and distributions with mean and variance.

## 9. Vectors

Direction ratio/cosines of vectors, addition of vectors, scalar multiplication, position vector of a point dividing a line segment in a given ratio.

Dot and cross products of two vectors, projection of a vector on a line.

Scalar triple products and their geometrical interpretations.

## 10. Statistics

Measures of dispersion

Analysis of frequency distributions with equal means but different variances

## 11. Linear Programming

Various terminology and formulation of linear Programming

Solution of linear Programming using graphical method, feasible and infeasible regions, feasible and infeasible solutions, optimal feasible solutions (upto three nontrivial constraints)

## 12. Mathematical modeling

Formulation of simple real life problem, solution using matrices, calculus and linear programming.

# Part IV: Biology

## 1: Diversity in Living World

Biology – its meaning and relevance to mankind

What is living; Taxonomic categories and aids; Systematics and Binomial system of nomenclature.

Introductory classification of living organisms (Two-kingdom system, Five-kingdom system);

Plant kingdom – Salient features of major groups (Algae to Angiosperms);

Animal kingdom – Salient features of Nonchordates up to phylum, and Chordates up to class level.

## 2: Cell: The Unit of Life; Structure and Function

Cell wall; Cell membrane; Endomembrane system (ER, Golgi apparatus/Dictyosome, Lysosomes, Vacuoles); Mitochondria; Plastids; Ribosomes; Cytoskeleton; Cilia and Flagella; Centrosome and Centriole; Nucleus; Microbodies.

Structural differences between prokaryotic and eukaryotic, and between plant and animal cells.

Cell cycle (various phases); Mitosis; Meiosis.

Biomolecules – Structure and function of Carbohydrates, Proteins, Lipids, and Nucleic acids.

Enzymes – Chemical nature, types, properties and mechanism of action.

## 3: Genetics and Evolution

Mendelian inheritance; Chromosome theory of inheritance; Gene interaction; Incomplete dominance; Co-dominance; Complementary genes; Multiple alleles;

Linkage and Crossing over; Inheritance patterns of hemophilia and blood groups in humans.

DNA –its organization and replication; Transcription and Translation;

Gene expression and regulation; DNA fingerprinting.

Theories and evidences of evolution, including modern Darwinism.

## 4: Structure and Function – Plants

Morphology of a flowering plant; Tissues and tissue systems in plants; Anatomy and function of root, stem (including modifications), leaf, inflorescence, flower (including position and arrangement of different whorls, placentation), fruit and seed; Types of fruit; Secondary growth;

Absorption and movement of water (including diffusion, osmosis and water relations of cell) and of nutrients; Translocation of food; Transpiration and gaseous exchange; Mechanism of stomatal movement.

Mineral nutrition – Macro- and micro-nutrients in plants including deficiency disorders; Biological nitrogen fixation mechanism.

Photosynthesis – Light reaction, cyclic and non-cyclic photophosphorylation; various pathways of carbon dioxide fixation; Photorespiration; Limiting factors.

Respiration – Anaerobic, Fermentation, Aerobic; Glycolysis, TCA cycle; Electron transport system; Energy relations.

## 5: Structure and Function - Animals

Human Physiology – Digestive system – organs, digestion and absorption; Respiratory system – organs, breathing and exchange and transport of gases.

Body fluids and circulation – Blood, lymph, double circulation, regulation of cardiac activity; Hypertension, Coronary artery diseases.

Excretion system – Urine formation, regulation of kidney function

Locomotion and movement – Skeletal system, joints, muscles, types of movement.

Control and co-ordination – Central and peripheral nervous systems, structure and function of neuron, reflex action and sensory reception; Role of various types of endocrine glands; Mechanism of hormone action.

## 6: Reproduction, Growth and Movement in Plants

Asexual methods of reproduction;

Sexual Reproduction – Development of male and female gametophytes; Pollination (Types and agents); Fertilization; Development of embryo, endosperm, seed and fruit (including parthenocarpy and elminth).

Growth and Movement – Growth phases; Types of growth regulators and their role in seed dormancy, germination and movement;

Apical dominance; Senescence; Abscission; Photo- periodism; Vernalisation;  
Various types of movements.

### **7: Reproduction and Development in Humans**

Male and female reproductive systems;  
Menstrual cycle; Gamete production; Fertilisation; Implantation;  
Embryo development;  
Pregnancy and parturition;  
Birth control and contraception.

### **8: Ecology and Environment**

Meaning of ecology, environment, habitat and niche.

Ecological levels of organization (organism to biosphere);  
Characteristics of Species, Population, Biotic Community and  
Ecosystem; Succession and Climax. Ecosystem – Biotic and  
abiotic components; Ecological pyramids; Food chain and Food  
web;

Energy flow; Major types of ecosystems including agroecosystem.

Ecological adaptations – Structural and physiological features in  
plants and animals of aquatic and desert habitats.

Biodiversity and Environmental Issues – Meaning, types and  
conservation strategies (Biosphere reserves, National parks and  
Sanctuaries), Air and Water Pollution (sources and major  
pollutants); Global warming and Climate change; Ozone depletion;  
Noise pollution; Radioactive pollution; Methods of pollution control  
(including an idea of bioremediation); Deforestation; Extinction of  
species (Hot Spots).

### **9: Biology and Human Welfare**

Animal husbandry – Livestock, Poultry, Fisheries; Major animal  
diseases and their control. Pathogens of major communicable  
diseases of humans caused by fungi, bacteria, viruses, protozoans  
and helminthes, and their control.

Cancer; AIDS.

Adolescence and drug/alcohol abuse;

Basic concepts of immunology.

Plant Breeding and Tissue Culture in crop improvement.

### **10: Biotechnology and its Applications**

Microbes as ideal system for biotechnology;

Microbial technology in food processing, industrial production  
(alcohol, acids, enzymes, antibiotics), sewage treatment and  
energy generation.

Steps in recombinant DNA technology – restriction enzymes, NA  
insertion by vectors and other methods, regeneration of  
recombinants

Applications of R-DNA technology in human health –Production of  
Insulin, Vaccines and Growth hormones, Organ transplant, Gene

therapy.

Applications in Industry and Agriculture – Production of expensive enzymes, strain improvement to scale up bioprocesses, GM crops by transfer of genes for nitrogen fixation, herbicide- resistance and pest-resistance including Bt crops.