Syllabus for NEST 2016

General Section:
There is no specific syllabus for the General section. The aim is to test candidate's aptitude for a career in science. Questions are designed to test the candidate’s familiarity with (and not a detailed understanding of) major historical milestones in mathematics, physics, chemistry, biology, astronomy, computer science and environment. There will be some questions designed to test the grasp of mathematics up to 10th standard and application capabilities of the same to simple problems. Some questions in this section aim to test the candidate’s general ability to comprehend qualitative and quantitative aspects of a given scientific passage. This is done by giving a passage on some scientific topic and questions based on the concepts elaborated in the passage will be asked. Some questions aim to find whether the candidates can interpret graphical representation of information.

Biology

Cell Biology

Genetics and Evolution

Ecology

Humans and Environment
Soil, rainfall and temperature with reference to natural resources. Our natural resources - their uses and abuses. Environmental pollution and preventive measures. Biodiversity and conservation.

Biotechnology
Principles of recombinant DNA technology. Applications of biotechnology.

Biology of Animal systems

Respiratory System - Gaseous exchange in animals. Structure of respiratory organs, mechanism of breathing, gaseous transport, tissue respiration.


Nervous System - General account of brain, spinal cord and nerves. Reflex actions (simple and conditioned). Sense organs (eye and ear).
Reproductive System - Sexual and asexual reproduction. General arrangement and functions of reproductive organs.

Developmental Biology - Basic features of development in animals. Types of eggs, fertilization, cleavage, blastula. Stem cells - definition, types, uses, advantages and disadvantages, induced pluripotent stem cells. Different hormones and their roles.

Diversity of Animal Life — Principles of classification, binomial nomenclature. General classification of animal phyla up to classes (invertebrates) and upto sub-classes / order (vertebrates). General characters of fishes, amphibians, reptiles, birds and mammals.

Immunology - Basics of immune mechanisms and diseases - active and passive immunity, T and B cell responses, antigen presentation, principles of vaccination, monoclonal antibodies and their uses, immunology of AIDS.

Biology of Plant systems


Chemistry

Physical Chemistry

Measurements in chemistry: SI units for fundamental quantities, significant figures in calculations.

Mole concept: Avogadro number and mole concept, molar masses, mole fraction, molarity, molality, percent composition, stoichiometry. Equivalent weight and normality. Calculations based on mole concept and stoichiometry of different reactions. Oxidation-reduction reactions.


Chemical kinetics: Rates of chemical reactions. Order of reaction, rate constant. First order and pseudo first order reactions. Factors affecting rate of reaction – concentration, temperature (Arrhenius equation), catalyst.

Solid state: Classification of solids, amorphous and crystalline solids, crystalline state, crystal lattice and unit cells; seven crystal systems (cell parameters $a$, $b$, $c$, $\alpha$, $\beta$, $\gamma$), close packed structure of solids (cubic), packing in fcc, bcc and hcp lattices. Packing efficiency, nearest neighbours, ionic radii. Simple ionic compounds, Imperfection in solids, point defects. Electrical and magnetic properties, band theory of metals.


Surface chemistry:

Inorganic Chemistry
Classification of elements and periodicity in properties: Modern periodic table, classification of elements, periodic trends in properties of elements – valence, oxidation state, atomic/ionic radius, ionization energy, electron gain energy, electronegativity, valency, chemical reactivity. Diagonal relationship. Anomalous behaviours of Li, Be, B, C.


s-Block elements (Alkali and alkaline earth elements) – General characteristics and trends in properties.
(a) Group 1: Preparation, properties and reactions of alkali metals with emphasis on chemistry of Na and K and their compounds - oxides, peroxides, hydroxides, carbonates, bicarbonates, chlorides and sulphates. Uses.
(b) Group 2: Preparation, properties and reactions alkaline earth metals with emphasis on the chemistry of Mg and Ca and their compounds - oxides, peroxides, hydroxides, carbonates, bicarbonates, chlorides and sulphates. Uses.

p-Block elements: General characteristics and trends in properties.
(a)Group 13: Chemistry of Boron and its compounds - borax, boric acid and diborane.
(b) Group 14, 15 and 16: Chemistry of carbon, sulphur, nitrogen and phosphorus. Allotropy. Chemistry of oxides and oxyacids of these elements. Phosphines, phosphorus chlorides, ammonia, peroxide and ozone; silicones, silicon tetrachloride and silicates.
(c) Group 17: Chemistry of halogens, chemistry of chlorine in detail. Interhalogen compounds. HX and oxyacids of halogens.
(d) Group 18: Isolation, properties and reactions of inert gases with emphasis on chemistry of Xenon.

d-Block elements: (Mainly 3d elements) General characteristics and trends in properties. Variable oxidation states and their stabilities, colour (excluding the details of electronic transitions) and calculation of spin-only magnetic moment. Catalytic properties. Interstitial compounds, alloy formation. Preparation and properties of potassium dichromate and permanganate.
f- Block elements: (mainly lanthanides) General characteristics and trends in properties. Variable oxidation states. Lanthanide contraction and its consequences.

Coordination compounds: Nomenclature of mononuclear coordination compounds. Isomerism. Hybridization and geometries of mononuclear coordination compounds. Magnetic properties. Werner’s theory, VBT, CFT.


Organic Chemistry


Reactive intermediates: Homolytic and heterolytic bond cleavages. Formation, structure and stability of - carbocation, carbanion and free radical.


Nomenclature: IUPAC nomenclature of simple organic compounds (only hydrocarbons, mono-functional and bi-functional compounds), including benzene derivatives.


Haloarenes: Nucleophilic aromatic substitution in haloarenes and substituted haloarenes (excluding Benzene mechanism and Cine substitution).


Phenols: Preparation of phenol from halobenzene, cumene and benzene sulphonic acid. Acidity.
Reactions of phenols - halogenation, nitration, sulphonation, with Zn. Reimer-Tieman reaction, Kolbe reaction.

**Ethers:** Preparation by Williamson's Synthesis, dehydration of alcohols. Reaction with \( \text{H}_2\text{O}, \text{HX} \).


**Polymers:** Classification. Homo and co-polymers, Addition and condensation polymerizations. Polythene, nylons, polyetsres, Bakelite, melamine-formaldehyde, rubber – natural and synthetic.

### Mathematics

**Algebra**

Algebra of complex numbers, addition, multiplication, conjugation, polar representation, properties of modulus and principal argument, triangle inequality, cube roots of unity, geometric interpretations.

Quadratic equations with real coefficients, relations between roots and coefficients, formation of quadratic equations with given roots, symmetric functions of roots.

Arithmetic, geometric and harmonic progressions, arithmetic, geometric and harmonic means, 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.

Permutations and combinations, Binomial theorem for positive integral index, properties of binomial coefficients. Matrices as a rectangular array of real numbers, equality of matrices, addition, multiplication by a scalar and product of matrices, transpose of a matrix, determinant of a square matrix of order up to three, inverse of a square matrix of order up to three, properties of these matrix operations, diagonal, symmetric and skew-symmetric matrices and their properties, solutions of simultaneous linear equations in two or three variables.

Addition and multiplication rules of probability, conditional probability, Bayes Theorem, independence of events, computation of probability of events using permutations and combinations.

**Trigonometry**

Trigonometric functions, their periodicity and graphs, addition and subtraction formulae, formulae involving multiple and sub-multiple angles, general solution of trigonometric equations.
Relations between sides and angles of a triangle, sine rule, cosine rule, half-angle formula and the area of a triangle, inverse trigonometric functions (principal value only).

**Analytical geometry**

Two dimensions - Cartesian coordinates, distance between two points, section formulae, shift of origin. Equation of a straight line 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, concurrency of lines. Centroid, orthocentre, incentre and circumcentre of a triangle.

Equation of a circle in various forms, equations of tangent, normal and chord. Parametric equations of a circle, intersection of a circle with a straight line or a circle, equation of a circle through the points of intersection of two circles and those of a circle and a straight line.

Equations of a parabola, ellipse and hyperbola in standard form, their foci, directrices and eccentricity, parametric equations, equations of tangent and normal. Locus Problems.

Three dimensions - Direction cosines and direction ratios, equation of a straight line in space, equation of a plane, distance of a point from a plane.

**Differential calculus**

Real valued functions of a real variable, into, onto and one-to-one functions, sum, difference, product and quotient of two functions, composite functions, absolute value, polynomial, rational, trigonometric, exponential and logarithmic functions.

Limit and continuity of a function, limit and continuity of the sum, difference, product and quotient of two functions, L'Hospital rule for evaluation of limits of functions.

Even and odd functions, inverse of a function, continuity of composite functions, intermediate value property of continuous functions. Derivative of a function, derivative of the sum, difference, product and quotient of two functions, chain rule, derivatives of polynomial, rational, trigonometric, inverse trigonometric, exponential and logarithmic functions.

Derivatives of implicit functions, derivatives up to order two, geometrical interpretation of the derivative, tangents and normals, increasing and decreasing functions, maximum and minimum values of a function, Rolle's Theorem and Lagrange's Mean Value Theorem.

**Integral calculus**

Integration as the inverse process of differentiation, indefinite integrals of standard functions, definite integrals and their properties, Fundamental Theorem of Integral Calculus.

Integration by parts, integration by the methods of substitution and partial fractions, application of definite integrals to the determination of areas involving simple curves.


**Vectors**

Addition of vectors, scalar multiplication, dot and cross products, scalar triple products and their geometrical interpretations.

**Physics**

**General:** Units and dimensions, dimensional analysis. least count, significant figures. Methods of measurement (Direct, Indirect, Null) and measurement of length, time, mass, temperature, potential difference, current and resistance.
Design of some simple experiments, such as: i) Searle’s method to determine Young's modulus, ii) determination of 'g' by simple pendulum, iii) speed of sound using resonance tube, iv) coefficient of friction using angle of repose, v) determination of focal length of a convex lens by plotting a graph between 'u' and 'v', vi) refractive index of material of prism using the method of minimum deviation, vii) verification of Ohm's law, viii) resistance of galvanometer using half deflection method, ix) specific heat of a liquid using calorimeter, x) I-V characteristic curve for p-n junction in forward and reverse bias.

Graphical representation and interpretation of data. Errors in the measurements and error analysis.


Hooke’s law and stress – strain relations. Elastic limit, plastic deformation. Young’s modulus, bulk and shear moduli.


**Sound and mechanical waves:** Plane wave motion, longitudinal and transverse waves, superposition of waves. Progressive and stationary waves. Vibration of strings and air columns. Resonance (qualitative understanding). Beats. Speed of sound in gases. Doppler effect.


**Electricity and magnetism:** Coulomb’s law. Electric field and potential. Electrical potential energy of a system of point charges and of electrical dipoles in a uniform electrostatic field; Electric field lines. Flux of electric field. Gauss’s law and its application in simple cases, such as to find field due to infinitely long straight wire. uniformly charged infinite plane sheet and uniformly charged thin spherical shell.


Biot-Savart’s law and Ampere’s law. Magnetic field near a current carrying straight wire, along the axis of a circular coil and inside a long straight solenoid. Force on a moving charge and on a current carrying wire in a uniform magnetic field.

Magnetic moment of a current loop. Effect of a uniform magnetic field on a current loop. Moving coil galvanometer, voltmeter, ammeter and their conversions.

Electromagnetic induction - Faraday’s law, Lenz’s law. Self and mutual inductance. RC, LR and LC
circuits with and A.C. Sources.

