**Syllabus for Screening test for the post of Masters/Mistress of various subjects.**

**For The post of Masters/Mistress Difficulty Level of the Questions will be of Graduation Level.**

# Chemistry

## Physical Chemistry

1. **Basic principles of chemistry**:- Importance of chemistry, Nature of Matter, Properties of Matter and their measurement, Uncertainty in measurements, Laws of chemical combinations, Dalton's Atomic Theory, Atomic and Molecular Masses,Mole concept and molar masses Percentage Composition, [illegible]
2. **Atomic structure:-** Sub atomic Particles, Atomic models, Developments Leading to the Bohr's model of atom, Bohr's Model for hydrogen atom, [illegible], Quantum mechanical model of Atom, Nature of electromagnetic radiation, photoelectric effect limitations of Bohr's model, Dual nature of matter, de-Broglie's relationship, Heisnberg uncertaintiy principle, various quantum numbers( principal, angular momentum and magnetic quantum numbers) and their significance, shapes of s,p and d – orbitals, electron spin quantum number, Rules for filling electrons in orbitals-aufbau principle , Paulli's exclusion principle and Hund's rule, electronic configuration of elements, extra stability of half- filled and completely filled orbitals.
3. **States of Matter:-**Intermolecular Forces,Thermal Energy, Intermolecular forces vs thermal interactions, The Gascous state, The Gas laws, Ideal gas equation, Kinetic Molecular theory of Gases, Liquification of Gases, Liquid state
4. **Chemical Bonding and Molecular Structure:-**Kossel – Lewis approach to chemical bond formation, concept of ionic and covalent bonds, Ionic Bonding, Formation of Ionic bonds, factors affecting the formation of ionic bonds, calculation of lattice enthalpy, Covalent Bonding, Concept of electronegetavitiy, Fajan's rule, dipole moment, Valence Shell Electron Pair Repulsion(VSEPR) theory and shapes of simple molecules, Quantum mechanical approach to covalent bonding , Valence bond

theory – its important features, concept of hybridization involving s,p and d orbitals, Resonance, Molecular Orbital Theory ,LCAOs , types of molecular orbitals (bonding, antibonding), sigma and pi-bonds, molecular orbitals electronic configurations of homonuclear diatomic molecules, concept of bond order, bond length and bond energy , Elementary idea of metallic bonding , Hydrogen bonding and its applications.

5. **Basic principles and applications of spectroscopy:-** Rotational, vibrational, electronic, Raman, ESR, NMR

6. **Thermodynamics:-** Fundamental of thermodynamics , System and surroundings, extensive and intensive properties, state functions, types of processes, First law of thermodynamics ,concept of work, heat internal energy and enthalpy , heat capacity, molar heat capacity, Hess's law of constant heat summation , Enthalpies of bond dissociation, combustion ,formation, atomization,sublimation , phase transition, hydration, ionisationand solution. Second law of thermodynamics, Spontaneity of processes, $\Delta S$ of the universe and $\Delta G$ of the s system as criteria for spontaneity, $\Delta G^\circ$ (standard Gibbs energy change) and equilibrium constant.

7. **Equilibrium:-** Meaning of equilibrium, concept of dynamic equilibrium. Equilibria involving physical processes: Solid - liquid, liquid - gas and solid - gas equilibria, Henry's law, general characterics of equilibrium involving physical processes. Equilibria involving chemical process: Law of chemical equilibrium, equilibrium constants (Kp and Kc) and their significance, significance of $\Delta G$ and $\Delta G^\circ$ in chemical equilibria, factors affecting equilibrium concentration, pressure, temperature, effect of catalyst; Le Chatelier's principle. Ionic equilibrium: Weak and strong electrolytes, ionization of electrolytes, various concepts of acids and bases (Arthenius Bronsted - Lowry and Lewis) and their ionization, acid - base equilibria (including multistage ionization) and ionization constants, ionization of water, pH scale, common ion effect, hydrolysis of salts and pH of their solutions, solubility of sparingly soluble salts and solubility products, buffer solutions.

8. **Redox Reactions and Electrochemistry:-** Electronic concept of oxidation and reduction, redox reactions, oxidation number, rules for assigning oxidation number, balancing of redox reactions. Eectrolytic and metallic

conduction, conductance in electrolytic solutions, specific and molar conductivities and their variation with concentration: Kohlrausch's law and its applications. Electrochemical cells - Electrolytic and Galvanic cells, different types of electrodes, electrode potentials including standard electrode potential, half-cell and cell reactions, emf of a Galvanic cell and its measurement; Nernst equation and its applications; Relationship between cell potential and Gibbs' energy change, Dry cell and lead accumulator; Fuel cells.

9. **Chemical Kinetics:-** Rate of a chemical reactions, factors affecting the rate of reactions: concentration, temperature, pressure and catalyst; elementary and complex reactions, order and molecularity of reactions, rate law, constant and its units, differential and integral forms of zero and first order reactions, their characteristics and half-lives, effect of temperature on rate of reactions - Arrhenius theory, activation energy and its calculation, collision theory of bimolecular gaseous reactions (no derivation).

10. **Surface chemistry:-** Adsorption - Physisorption and chemisorptions and their characteristics, factors affecting adsorption of gases on solids - Freundlich and Langmuir adsorption isotherms, adsorption from solutions, Colliodal state - distinction among true solutions, colloids and suspensions, classification of colloids - lyophilic, lyophobic; multi molecular, macromolecular and associated colloids (micelles), preparation and properties of colloids - Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation; Emulsions and their characteristics.

11. **Solid States-:** General Characteristics of solid state, Amorphous and Crystalline Solids, Classification of Crystalline Solids, Crystal Lattices and Unit Cell, Close-Packed Structures, Packing Efficiency, Calculations Involving Unit Cell Dimensions, Imperfections in Solids, Electrical Properties, Magnetic Properties.

12. **Concepts of catalysis:-** Homogenous and heterogeneous catalysis,

13. **Solutions:-** Types of Solutions, Expressing concentration of solutions, Solubility, Vapour pressure of liquid solutions, Ideal and Non-ideal solutions, Colligative Properties and Determination of Molar Mass, Abnormal Molar Masses

## Inorganic Chemistry

1. **Chemical periodicity:-** Modern periodic law and present form of the periodic tables, s, p, d and f block elements, periodic trends in properties of elements atomic and ionic radii, ionization enthalpy, electron gain enthalpy, electro negativity valence, oxidation states and chemical reactivity.
2. **General principles & process of isolation of metals:-** Modes of occurrence of elements in nature, minerals, ores; Steps involved in the extraction of metals - concentration, reduction (chemical and electrolytic methods) and refining with special reference to the extraction of Al, Cu, Zn and Fe; ~~Thermodynamic and electrochemical principles involved in the extraction of metals~~.
3. **Hydrogen:-** Position of hydrogen in periodic table, isotopes, preparation, properties and uses of hydrogen; Physical and chemical properties of water and heavy water, ~~Structure preparation, reactions~~ and ~~uses of hydrogen peroxide~~; Hydrogen as a fuel.
4. **S-Block elements:-** Group-1 and 2 elements introduction, electronic configuration and general trends in physical and chemical properties of elements, anomalous properties of the first element of each group, diagonal relationships. Preparation and properties of some important compounds - sodium carbonate and sodium hydroxide; Industrial uses of lime, limestone Plaster of Paris and cement; Biological significance of Na, K, Mg and Ca.

**P-Block elements:-** Group 13 to Group 18 elements, Electronic configuration general trends in physical and chemical properties of elements across the periods and down the group; unique behavior of the first element in each group. Preparation, properties and uses of boron and aluminium; properties of boric acid, diboron, boron trifluride, aluminium chloride and alums, Allotropes of carbon.

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# BioLogy

## Unit I Diversity in Living World

- **Biology-** its meaning of relevance to mankind
- **Taxonomy** – Concept of species and taxonomical hierarchy
- **Systematic** – Introduction to plant Systematic, its aims , objectives and importance , classification , brief history , introduction , various systems of classification of living organism [Two kingdom system , five kingdom system) Brief introduction to nomenclature and binomial system of nomenclature
- **Salient features and classification of kingdom Monera** ( including Archaebacteria and cyno bacteria ) General structure ,occurrence ,reproduction and economics importance.
- **Kingdom protista-** General structure ,occurrence , reproduction and economic importance
- **Kingdom Fungi-** General structure, occurrence, reproduction and economic importance, diseases of economically important crop plant
- **Kingdom Plantae-** salient features and classification of plants into major groups.
  Algae- General account, structure, life cycle of biological importance of green algae, brown algae and red algae .
  Bryophytes- General account , structure, life cycle and economic importance of liverworts and mosses.
- **Pteridophytes-** General account , structure, classification, life cycle and economic importance.
- **Gymnosperms-** General account , structure, classification life cycle and economic importance.
- **Angioperms-** classification up to class ,General account , structure, life cycle and economic importance.
  Viruses- General structure Lichens- General account **Kingdom Animalia** – salient features ( in the reference to habitat , habits morphology and economic importance )and classification of non chordates up to phylum level.
  Salient features ( in the reference to habitat , habits, morphology and economic importance ) classification of chordates up to class level.

## Unit II Structural organization in plants

- **Cell, Tissue**
- **Morphology**, function and modification of root , stem and leaf
- **Anatomy** of root , stem and leaf , primary and secondary growth in dicot stem

- **Inflorescence**, Types of Inflorescence, flower ( including postion and arrangement of different whorls ) placentation , fruit, types of fruit, seed.

## Unit III Plant Physiology

**Transport in Plants** - Movement of water ( including diffusion ,osmosis, plasmolysis and water relations of cell ) and nutrients, long distant of water – absorption, apoplast , symplast , transpiration pull, root pressure and guttation , transpiration opening and closing of stomata, uptake and translocation of mineral nutrients- Transport of food ,phloem transport

**Nitrogen Metabolism** - Biological nitrogen fixation , Nitrogen cycle.

**Photosynthesis** - Photosynthesis as means of autotrophic nutrition, pigments involved in Photosynthesis , , photochemical and biosynthetic phases of Photosynthesis, photophosphorylation :, photorespiration, factors affecting Photosynthesis.

**Respiration**- Aerobic respiration : Glycolysis; Kerbs's cycle , Anaerobic respiration , respiratory substance and respiratory quotient

**Plant Growth and development** – phases of plant growth and plant growth rate , canditions of growth , Differentiation, and dedifferentiation, Redifferentiation Growth regulators – Role of auxins, gibberllin, cytokinin, ethylene, abscissic acid photoperiodism, role of phytochrome and harmones in photoperiodism, Dormancy, methods of breaking seed dormancy, vernalization.

**Plant movements**- Tropic movements ,phototropism ,geotropism and their mechanism, Nastic movements.

## Unit IV Strutural organization in Animals

-Tissue in animals

- Morphology, anatomy and function of different systems ( digestive, circulatory respiratory, nervous and reproductive )
of earthworm, frog and an insect ( Cockroach )

## Unit V Animal Physiology

**Human Physiology**

**Digestion and absorption** :- Alimentary canal and digestive glands , role of digestive enzymes and gastrointestinal hormones , digestion, absorption and assimilation of proteins carbohydrates and fats, egestion , nutrition and digestive disorders.

**Breathing and respiration** – respiratory organs in human beings , Mechanism of Breathing and its regulation in human, Transport of respiratory gases, Respiratory volumes , respiratory disorders .

**Circulation**

Composition of Blood , Blood groups, coagulation of blood , composition of lymph and its functions , structure of human heart and blood vessels , Cardiac cycle, Cardiac output, ECG , double circulation , Disorders of circulatory systems .

**Excretion**- Modes of excretion, structure and function of excretory system , Urine formation , osmoregulation, Regulation of kidney function , role of other organs in excretion , Disorders of excretory system.

- **Locomotion and Movement** ;- Types of movement, skeletal system and its function , joints. Disorders of muscular and skeletal system **Neural control and coordination:** Neuron and nerves; Nervous system in humans- central nervous system, peripheral nervous system and visceral nervous system; Generation and conduction of nerve impulse; Reflex action; Sense organs; Elementary structure and function of eye and ear.
- **Chemical coordination and regulation:** Endocrine glands and hormones; Human endocrine system-Hypothalamus, Pituitary, Pineal, Thyroid, Parathyroid, Adrenal, Pancreas, Gonads; Role of hormones as messengers and regulators, Hypo-and hyperactivity and related disorders (Common disorders e.g. Dwarfism)

## Unit VI Reproduction

**Reproduction in organisms:** Reproduction, a characteristic feature of all organisms for continuation of species; Modes of reproduction – Asexual and sexual; Asexual reproduction; Modes-Binary fission, sporulation, budding, gemmule, fragmentation; vegetative propagation in plants.

**Sexual reproduction in flowering plants:** Flower structure; Development of male and female gametophytes; Pollination-types, agencies and examples; Pollen-Pistil interaction; Double fertilization; Post fertilization events-Development of endosperm and embryo, Development of seed and formation of fruit; Special modes-apomixis, parthenocarpy, polyembryony; Significance of seed and fruit formation.

**Human Reproduction:** Male and female reproductive systems; Gametogenesis-spermatogenesis & oogenesis; Menstrual cycle; Fertilisation, embryo development upto blastocyst formation, implantation; Pregnancy and placenta formation (Elementary idea); Parturition (Elementary idea); Lactation (Elementary idea).

**Reproductive health:** Need for reproductive health and prevention of sexually transmitted diseases (STD); Birth control-Need and Methods, Contraception and Medical Termination of Pregnancy (MTP); Amniocentesis;).

## Unit VII **Cell biology, genetics** and **Evolution**.

Structure and function of bio molecules : Carbohydrates,lipids proteins, and nucleic acid.

Enzymes- types,properties,functions and enzymes action

Cell-physico-chemical nature of plasma membrane , cell wall.

cell organelles with brief description and functions.

1. Endoplasmicreticulum, golgibodies, lysosome, vacuoles, mitochondria, ribosomes, plastids, cilia, flagella, centrioles nucleolus.
2. Cell division : cell cycle, mitosis , meiosis and their significance.

Heredity and variation: Mendelian Inheritance; Deviations from Mendelism-Incomplete dominance, and Inheritance of blood groups, Pleiotropy; Elementary idea of polygenic inheritance; Chromosome theory of inheritance; Chromosomes and genes; Sex determination- In humans, birds; Linkage and crossing over; Sex linked inheritance-Haemophilia, Colour blindness; Chromosomal disorders in humans; Down's syndrome, Turner's and Klinefelter's syndromes.

Molecular basis of Inheritance: Search for genetic material and DNA as genetic material; Structure of DNA and RNA; DNA finger printing.

Evolution: Origin of life; Biological evolution and evidences for biological evolution from Paleontology, comparative anatomy, embryology and molecular evidence); lamarcks theory of evolution Darwin's contribution, Modern Synthetic theory of Evolution; Mechanism of evolution-Variation (Mutation and Recombination) and Natural Selection with examples, types of natural selection; Gene flow and genetic drift; Hardy-Weinberg's principle;Human evolution.

**UNIT VIII Biology and Human Welfare**

Health and Disease: Pathogens; parasites causing human diseases (Malaria, Filariasis, Ascariasis. Typhoid, Pneumonia, common cold, amoebiasis, ring worm); Basic concepts of immunology-vaccines; Cancer, HIV and AIDS; Adolescence, drug and alcohol abuse.

Improvement in food production; Plant breeding, tissue culture,; Apiculture and Animal husbandry.

Microbes in human welfare: In household food processing, industrial production, sewage treatment, energy generation and as biocontrol agents and biofertilizers.

**UNIT IX Biotechnology and Its Applications**

- Principles and process of Biotechnology: Genetic engineering (Recombinant DNA technology).

- Application of Biotechnology in health and agriculture: Human insulin and vaccine production, gene therapy; Genetically modified organisms-Bt crops; Transgenic Animals; Biosafety issues-Biopiracy and patents.

**UNIT X Ecology and environment**

- Organisms and environment: Habitat and niche; Population and ecological adaptations; Population interactions-mutualism, competition, predation, parasitism; Population attributes-growth, birth rate and death rate.

- Ecosystem: Patterns, components; productivity and decomposition; Energy flow; Pyramids of number, biomass, energy; Nutrient cycling (carbon and phosphorous); Ecological succession;. Biogeochemical cycle

- Biodiversity and its conservation: Concept of Biodiversity; Patterns of Biodiversity; Importance of Biodiversity; Loss of Biodiversity; Biodiversity conservation; Hotspots, endangered organisms, extinction, Red Data Book, biosphere reserves, National parks and sanctuaries.

- Environmental issues: Air pollution and its control; Water pollution and its control; Agrochemicals and their effects; Solid waste management; Radioactive waste management; Greenhouse effect and global warning; Ozone depletion; Deforestation.

# PHYSICS

## I. Mathematical Methods of Physics

Dimensional analysis; Vector algebra and vector calculus; Linear algebra, matrices, Cayley Hamilton theorem, eigenvalue problems; Linear differential equations; Special functions (Hermite, Bessel, Laguerre and Legendre); Fourier series, Fourier and Laplace transforms; Elements of complex analysis: Laurent series-poles, residues and evaluation of integrals; Elementary ideas about tensors; Introductory group theory, SU(2), O(3); Elements of computational techniques: roots of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, solution of first order differential equations using Runge-Kutta method; Finite difference methods; Elementary probability theory, random variables, binomial, Poisson and normal distributions.

## II. Classical Mechanics

Newton's laws; Phase space dynamics, stability analysis; Central-force motion; Two-body collisions, scattering in laboratory and centre-of-mass frames; Rigid body dynamics, moment of inertia tensor, non-inertial frames and pseudoforces; Variational principle, Lagrangian and Hamiltonian formalisms and equations of motion; Poisson brackets and canonical transformations; Symmetry, invariance and conservation laws, cyclic coordinates; Periodic motion, wave motion, small oscillations and normal modes; Special theory of relativity, Lorentz transformations, relativistic kinematics and mass–energy equivalence, work power energy, gravitation, pressure, motion of fluids, viscosity, surface tension.

## III. Electromagnetic Theory

Electrostatics: Gauss' Law and its applications; Laplace and Poisson equations, boundary value problems; Magnetostatics: Biot-Savart law, Ampere's theorem, electromagnetic induction; Maxwell's equations in free space and linear isotropic media; boundary conditions on fields at interfaces,; Scalar and vector potentials; Gauge invariance; Electromagnetic waves in free space, dielectrics, and conductors; Reflection and refraction, polarization, optical instrument, defects of eye. Fresnel's Law, interference, coherence, and diffraction; Dispersion relations in plasma; Lorentz invariance of Maxwell's equations; Transmission lines and wave guides; Dynamics of charged particles in static and uniform electromagnetic fields; Radiation from moving charges, dipoles and retarded potentials, **current electricity**-Kirchhoff's Law, Wheat Stone Bridge, Potentio meter & Slide Wire Bridge.

## IV. 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); Eigenvalue 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 momenta; 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.

## V. Thermodynamic and Statistical Physics

Laws of thermodynamics and their consequences; Thermodynamic potentials, Maxwell relations; Chemical potential, phase equilibria; Phase space, micro- and macrostates; Microcanonical, canonical and grand-canonical ensembles and partition functions; Free Energy and connection with thermodynamic quantities; First- and second-order phase transitions; Classical and quantum statistics, ideal Fermi and Bose gases; Principle of detailed balance; Blackbody radiation and Planck's distribution law; Bose-Einstein condensation; Random walk and Brownian motion; Introduction to non-equilibrium processes; Diffusion equation.

## VI. Electronics and Experimental methods

Semiconductor device physics, including diodes, junctions, transistors, field effect devices, homo and heterojunction devices, device structure, device characteristics, frequency dependence and applications; Optoelectronic devices, including solar cells, photodetectors, and LEDs; High-frequency devices, including generators and detectors; Operational amplifiers and their applications; Digital techniques and applications (registers, counters, comparators and similar circuits); A/D and D/A converters; Microprocessor and microcontroller basics, Logic gates, communication system.

Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting.

## VII. Experimental Techniques and data analysis

Data interpretation and analysis; Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Transducers (temperature, pressure/vacuum, magnetic field, vibration, optical, and particle detectors), measurement and control; Signal conditioning and recovery, impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding; Fourier transforms; lock-in detector, box-car integrator, modulation techniques.

Applications of the above experimental and analytical techniques to typical undergraduate and graduate level laboratory experiments.

## VIII. Atomic & Molecular Physics

Quantum states of an electron in an atom; Electron spin; Stern-Gerlach experiment; Spectrum of Hydrogen, helium and alkali atoms; Relativistic corrections for energy levels of hydrogen; Hyperfine structure and isotopic shift; width of spectral lines; LS & JJ coupling; Zeeman, Paschen Back & Stark effect, Photoelectric effect, X-ray spectroscopy; Electron spin resonance, Nuclear magnetic resonance, chemical shift; Rotational, vibrational, electronic, and Raman spectra of diatomic molecules; Frank – Condon principle and selection rules; Spontaneous and stimulated emission, Einstein A & B coefficients; Lasers, optical pumping, population inversion, rate equation; Modes of resonators and coherence length.

## IX. Condensed Matter Physics

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding of solids; Elastic properties, phonons, lattice specific heat; Free electron theory and electronic specific heat; Response and relaxation phenomena; Drude model of electrical and thermal conductivity; Hall effect and thermoelectric power; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators and semiconductors; Superconductivity, type – I and type - II superconductors, Josephson junctions; Defects and dislocations; Ordered phases of matter, translational and orientational order, kinds of liquid crystalline order; Conducting polymers; Quasicrystals.

## X. Nuclear and Particle Physics

Basic nuclear properties: size, shape, charge distribution, spin and parity; Binding energy, semi-empirical mass formula; Liquid drop model; Fission and fusion; Nature of the nuclear force, form of nucleon-nucleon potential; Charge-independence and charge-symmetry of nuclear forces; Isospin; Deuteron problem; Evidence of shell structure, single- particle shell model, its validity and limitations; Rotational spectra; Elementary ideas of alpha, beta and gamma decays and their selection rules; Nuclear reactions, reaction mechanisms, compound nuclei and direct reactions; Classification of fundamental forces; Elementary particles (quarks, baryons, mesons, leptons); Spin and parity assignments, isospin, strangeness; Gell-Mann-Nishijima formula; C, P, and T invariance and applications of symmetry arguments to particle reactions, parity non-conservation in weak interaction; Relativistic kinematics.

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