Syllabus for Entrance Examination for Admission to M.Sc. Physics (under CBCS) Course for the Session 2019-2020.

NOTE: There will be total of 50 multiple choice questions of 2 marks each. Number of question from different units of the syllabus are indicated on the top of the each unit. Paper setters are requested to kindly set the number of questions accordingly.

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Classical Mechanics and Theory of Relativity (4 Questions)

Basic concepts of Classical mechanics: Mechanics of single and system of particles, Conversion law of linear momentum, Angular momentum and mechanical energy for a particle and a system of particles, Centre of Mass and equation of motion, Constrained Motion.

Generalized Notations: Degrees of freedom and Generalized coordinates, Transformation equations, Generalized Displacement, Velocity, Acceleration, Momentum, Force and Potential, Hamilton's variational principle, Lagrange's equation of motion from Hamilton's principle, Linear Harmonic oscillator, Simple pendulum, Atwood's machine.

Theory of relativity: Reference system, Inertial and Non-inertial frames, Galilean invariance and conservation laws, Newtonian Relativity Principle, Michelson-Morley experiment: search for ether, Lorentz transformations.

Applications of theory of relativity: Length Contraction, Time Dilation, Twin Paradox, Velocity addition theorem, Variation of mass with velocity, Mass energy equivalence.

Electricity, Magnetism and Electromagnetic theory (4 Questions)

Vector background and Electric field: Gradient of a scalar and its physical significance, Line, Surface and Volume integrals of a vector and their physical significance, Flux of a vector field, Divergence and curl of a vector and their physical significance, Gauss's divergence theorem, Stoke's theorem.

Derivation of electric field E from potential as gradient, Derivation of Laplace and Poisson equations, Electric flux, Gauss's Law, Mechanical force of charged surface, Energy per unit volume.

Magnetism: Magnetic induction, Magnetic flux, Solenoidal nature of vector field of induction, properties of $\vec{B}$ (i) $\vec{\nabla}.\vec{B} = 0$, (ii) $\vec{\nabla} \times \vec{B} = \mu\vec{j}$, Electronic theory of dia and paramagnetism, Domain theory of ferromagnetism (Langevin's theory), Cycle of magnetization- hystresis loop (Energy dissipation, Hystresis loss and importance of Hystresis Curve)

Electromagnetism: Maxwell equations and their derivations, Displacement current, Vector and Scalar potentials, Boundary conditions at interface between two different media, Propagation of electromagnetic wave (Basic idea, no derivation), Poynting vector and Poynting theorem.

A. C. Analysis: A.C. circuit analysis using complex variable with (a) Capacitance and Resistance (CR) (b) Resistance and Inductance (LR) (c) Capacitance and Inductance (LC) (D) Capacitance, Inductance (LR) (c) Capacitance and Inductance (LC) (d) Capacitance, Inductance and Resistance (LCR), Series and parallel resonance circuit, Quality factor (sharpness of resonance).

Properties of Matter and Kinetic Theory of Gases (3 Questions)

Kinetic theory of gases -I: Assumption of Kinetic theory of gases, pressure of an ideal gas (no derivation), Kinetic interpretation of Temperature, Ideal Gas equation, Degree of freedom, Law of equipartition of energy and is application for specific heat of gases, Real gases, Vander wall's equation, Brownian motion(Qualitative)

Kinetic theory of gases -II: Maxwell's distribution of speed and velocities (derivation required), Experimental verification of Maxwell's law of speed distribution: most probable speed, average and r.m.s. speed, Mean free path, Transport of energy and momentum, Diffusion of gases.

Semiconductor Devices (4 Questions)

Semiconductors: Energy bands in solids, Intrinsic and extrinsic semiconductors, p-n junction diode and their characteristics, Zener and Avalanche breakdown, Zener diode , Light emitting diodes (LED), Photoconduction in semiconductors, Photodiode, Solar Cell, P-n junction, half wave and full wave rectifiers, Zener diode as a voltage regulator.

Transistors: Junction transistors, Working of NPN and PNP transistors, Three configurations of transistor (C-B, C-E, C-C modes), Constants of a transistor, Relation between alpha and beta, Common base, Common emitter and common collector characteristics of transistor, Advantages and disadvantages of C-E configuration.

Transistor Amplifiers: Transistor biasing, Methods a of transistor biasing and stabilization, D.C. load line , Common base and Common emitter biasing, Common base and common emitter amplifiers, Classification of amplifiers, Resistance- Capacitance (RC) coupled amplifier (two stage, concept of band width, no derivation), Feedback in amplifiers, Advantages of negative feedback, Emitter follower.

Oscillators: Oscillators, Principle of oscillation, classification of oscillators, Condition for self sustained oscillation: Barkhausen criterion for oscillation, Tuned collector common emitter oscillator, Hartley oscillator, C.R.O. (Principle and Working).

Thermodynamics (4 Questions)

Thermodynamics-I

Second law of thermodynamics and statements, Carnot theorem, Absolute scale of temperature, Absolute Zero, Derivation of Clausius-Clapeyron and Clausius latent heat equation, Entropy, T-S diagram, Nernst heat law, Clausius theorem, Calculations of entropy of reversible and irreversible processes, Development of Maxwell thermodynamical relations.

Thermodynamics-II

Thermodynamic function: Internal energy (U), Helmholtz function (F), Enthalpy (H), Gibbs function (G) and the relations between them, Application of Maxwell relations in the derivation of relations between entropy, specific heats and thermodynamic variables, Phase diagram and triple point of a substance,

Joule's free expansion, Joule-Thomson (Porous plug) experiment, Joule Thomson effect, Liquefaction of gases, (air, hydrogen, helium), Solidifaction of He below 4K, Cooling by adiabatic demagnetization.

Wave and Optics (4 Questions)

Interference

Interference by Division of Wave front: Young's double slit experiment, Coherence, Conditions of interference, Fresnel's biprism and its applications to determination of wavelength of sodium light and thickness of a mica sheet, Lloyd's mirror, Difference between Bi-prism and Llyod mirror fringes, phase change on reflection.

Interference by Division of Amplitude: Thin film, Plane parallel film, Interference due to transmitted light, wedge shaped film, Newton's rings. Interferometers: Michelson's interferometer and its applications to (i) Standardization of a meter (ii) determination of wavelength.

Diffraction

Huygen's-Fresnel's theory, Fresnel's assumptions, rectilinear propagation of light, Fresnel's half-period zones, zone plate, diffraction at a straight edge, rectangular slit and diffraction at a circular aperture, Diffraction due to a narrow slit and diffraction due to a narrow wire

Fraunhoffer diffraction: one-slit diffraction, two slit diffraction, N-slit diffraction, plane transmission granting spectrum, dispersive power of grating, limit of resolution, Rayleigh's criterion, resolving power of telescope and a grating.

Polarization

Polarization and Double refraction, Polarisation by reflection, Polarisation by scattering, Malus Law, Phenomenon of double refraction, Huygen's wave theory of double refraction (Normal and oblique incidence), Analysis of polarized Light. Nicol prism, Quarter wave plate and half wave plate, production and detection of (i) Plane polarized light (ii) Circularly polarized light and (iii) Elliptically polarized light. Optical activity, Fresnel's theory of rotation, Specific rotation, Polarimeters (half shade and Biquartz).

Statistical Physics (4 Questions)

Statistical Physics-I

Probability and probability theorem, some probability considerations, combinations possessing maximum probability, combinations possessing minimum probability, Micro-Macro states, Constraints, Accessible states, Ensembles, Thermodynamical probability, general distribution of particles in compartments of different sizes, Condition of equilibrium between two systems in thermal contact, β parameter, Entropy and Probability, Boltzmann distribution law.

Statistical Physics II

Postulates of statistical physics, Phase space, Division of Phase space into cells, three kinds of statistics, basic approach in three statistics, M. B. statistics applied to an ideal gas in equilibrium- energy distribution law (including evaluation of α and β) , speed distribution law & velocity distribution law. Expression for average speed, r m s speed, average velocity, r m s velocity, most probable energy & mean energy for Maxwellian distribution.

Quantum Statistics

Classical vrs Quantum Statistics: Identical particles, Bose-Einstein Statistics, Fermi-Dirac statistics, Application of B.E Statistics of Planck's radiation law, B.E. gas, M. B. Law as a limiting case of B.E. Degeneracy and B.E. Condensation, F.D. gas, electron gas in metals, Zero point energy, Specific heat of metals and its solution.

Theory of Specific Heat of Solids

Dulong and Petit law, Derivation of Dulong and Petit law from classical physics. Specific heat at low temperature, Einstein theory of specific heat, Criticism of Einstein theory, Debye model of specific heat of solids, success and shortcomings of Debye, comparison of Einstein and Debye theory

Quantum Physics (6 Questions)

Origins of quantum physics

Overview, scale of quantum physics, boundary between classical and quantum phenomena, Photon, Photoelectric effect, Compton effect (theory and result), Frank-Hertz experiment, de-Broglie hypothesis. Davisson and Germer's experiment, ·G.P. Thomson experiment. Phase velocity, group velocity, Heisenberg's uncertainty principle. Time energy and angular momentum, position uncertainty. Uncertainty principle from de Broglie wave. (Wave-particle duality). Gamma Ray Microscope, Electron diffraction from a slit. Derivation of time-dependent Schrodinger wave equation (subject to force, free particle). Time-independent Schrodinger wave equation, eigen values, eigen functions, wave functions and its significance. Normalization of a function, concept of observer and operator.

Application of Schrodinger wave equation:

(i) Free particle in one-dimensional box (solution of Schrodinger wave equation, eigen functions, eigen values, quantization of energy and momentum, nodes and anti nodes, zero point energy).
(ii) One dimensional potential barrier, $E > V_o$ (Reflection and Transmission coefficient).
(iii) One-dimensional potential barrier, $E < V_o$ (Reflection coefficient, penetration or tunneling coefficient, penetration depth)
(iv) Solution of Schrodinger equation for harmonic oscillator (quantization of energy, Zero-point energy, wave equation for ground state and excited states).

Nuclear Physics (6 Questions)

Nuclear Structure and Properties of Nuclei

Nuclear composition, Nuclear properties; Nuclear size, spin, parity, statistics, magnetic dipole moment, quadrupole moment (shape concept). Determination of mass by Bain-Bridge, Bain-Bridge and Jordan mass spectrograph. Determination of charge by Mosley Law. Determination of size of nuclei by Rutherford Back Scattering. Nuclear mass and binding energy, systematic of nuclear binding energy, nuclear stability.

Nuclear Radiation decay Processes

Alpha-disintegration and its theory. Energetics of alpha-decay, Origin of continuous beta spectrum (neutrino hypothesis), types of beta-decay and energetics of beta-decay. Nature of gamma rays, Energetics of gamma rays.

Radiation interaction

Interaction of heavy charged particles (Alpha particles); Energy loss of heavy charged particle (idea of Bethe formula, no derivation), Range and straggling of alpha particles. Geiger-Nuttal law. Interaction of light charged particle (Beta-particle), Energy loss of beta-particles (ionization), Range of electrons, absorption of beta-particles. Interaction of Gamma Ray; Passage of Gamma radiations through matter (Photoelectric, Compton and pair production effect) electron-positron anhilation. Absorption of Gamma rays (Mass attenuation coefficient) and its application.

Nuclear Accelerators

Linear accelerator, Tendem accelerator, cyclotron and Betatron accelerators.

Nuclear Radiation Detectors.

Gas filled counters;Ionization chamber, proportional counter, G.M. Counter (detailed study), Scintillation counter and semiconductor detector.

Nuclear Reactions.

Nuclear reactions, Elastic scattering, Inelastic scattering, Nuclear disintegration, Photonuclear reaction, Radiative capture, Direct reaction, Heavy ion reactions and spallation Reactions. Conservation laws, Q-value and reaction threshold.

Nuclear Reactors.

Nuclear Reactors, General aspects of Reactor Design. Nuclear fission and fusion reactors, (Principle, construction, working and use).

Solid State Physics. (5 Questions)

Crystal Structure I

Crystalline and glassy forms, liquid crystals, crystal structure, periodicity, lattice and basis, crystal translational vectors and axes. Unit cell and Primitive Cell, Winger Seitz primitive Cell, symmetry operations for a two dimensional crystal, Bravais lattices in two and three dimensions. Crystal planes and Miller indices, Interplaner spacing, Crystal structures of Zinc Sulphide, Sodium Chloride and Diamond.

Crystal Structure II

X-ray diffraction, Bragg's Law and experimental X-ray diffraction methods. K-space and reciprocal lattice and its physical significance, reciprocal lattice vectors, reciprocal lattice to a simple cubic lattice, b.c.c. and f.c.c.

Super conductivity

Historical introduction, Survey of superconductivity, Super conducting systems, High Tc Super conductors, Isotopic effect, Critical magnetic field, Meissner effect, London theory and Pippards' equation, Classification of superconductors (type I and Type II), Theory of superconductivity, Flux quantization, Josephson effect (AC and DC), Practical applications of superconductivity and their limitations, Power application of superconductors.

Atomic and Molecular (6 Questions)

Historical background of atomic spectroscopy

Introduction of early observations, Atomic spectra, Bohr atomic model, spectral series of H. un-quantized states and continuous spectra, effect of nuclear motion on line spectra (correction of finite nuclear mass), variation in Rydberg constant due to finite mass, short comings of Bohr theory, Wilson Sommerfeld quantization rule, de-Broglie interpretation of Bohr quantization law, Bohr-Sommerfeld atom model, Sommerfeld relativistic correction, Fine structure of H line in Balmer series, Short comings of Bohr-Sommerfeld theory. Orbital magnetic dipole moment (Bohr megnaton), behavior of magnetic dipole in external magnetic filed, Larmors' precession and theorem, space quantization, Electron spin, Vector atom model, coupling of orbital and spin angular momentum, quantum numbers associated with vector atom model. Transition probability and selection rules

Vector Atom Model(single valance electron)

Spectra of Alkali Atoms and their theoretical interpretation, penetrating and Non-penetrating orbits, Penetrating orbits on the classical model; Quantum defect,Vector atom model ; observed doublet fine structure in the spectra of alkali metals. Interpretation of the doublet fine structure on the basis of vector atom model, spin orbit interaction energy of the single valance electron, spin orbit interaction for penetrating orbits.

Vector Atom model (two valance electrons)

term series and limits in 2 electron system, selection rules in atoms of two valance electrons, singlet and triplet series in two valance electron system, Coupling Schemes;
LS or Russell – Saunders Coupling Scheme and JJ coupling scheme, Interaction energy in two L-S coupling (sp, pd configuration), Pauli principal and periodic classification of the elements. Interaction energy in two JJ Coupling (sp, pd configuration), equivalent and non-equivalent electrons.Hyperfine structure of spectral lines and its origin;isotope effect,nuclear spin.

Atom in External Field

Zeeman Effect (normal and Anomalous) Zeeman pattern of D1 and D2 lines of Na-atom, Paschen-Back effect of a single valence electron system. Weak field Stark effect of Hydrogen atom.

Molecular Physics

General Considerations, Electronic States of Diatomic Molecules, Rotational Spectra (Far IR and Microwave Region), Vibrational Spectra (IR Region), Rotator Model of Diatomic Molecule, Raman Effect, Electronic Spectra.