St. Aloysius College (Autonomous), Jabalpur

Department of Physics

B. **Sc. III Year**

Paper I: Quantum Mechanics and Spectroscopy

Max. Marks: 40

Pass Marks: 13

Course Outcome

The students are expected to acquire the knowledge of the following:

- Aspects of the inadequacies of classical mechanics and historical development of quantum mechanics.
- Wave packets, Phase and Group Velocities and uncertainty principle.
- Wave functions, the Schrodinger time dependent and time independent equations, Solution of Schrodinger equation for different cases.
- Spectrum of Hydrogen Atom, Vector Atom model, Quantum numbers, Spectra of Alkali and Alkaline earth metals.
- Effect of magnetic fields on atoms.
- Vibrational and rotational motion of molecule and their energy levels, transition rules, spectrum, etc.
- Raman Spectra, Electronic spectra. Born-Oppenheimer approximation. Frank-Condon principle, Fluorescence and phosphorescence, etc.
- Properties of nuclei, liquid drop model and nuclear shell model.
- Decay rates and lifetime of radioactive decays, theory of beta decay, fission and fusion, stellar energy in stars.
- Experiments related to theory course.

Unit-I: QUANTUM MECHANICS-1 **[Lecture-15]**

Particles and Waves: Photoelectric effect. Black body radiation. Compton effect. De Broglie hypothesis. Wave particle duality. Davisson-Germer experiment. Wave packets. Concept of phase and group velocity. Two slit experiment with electrons. Probability. Wave amplitude and wave functions. Heisenberg's uncertainty principle with illustrations. Basic postulates and formalism of Schrodinger's equation. Eigenvalues. Probabilistic interpretation of wave function. Equation of continuity. Probability current density. Boundary conditions on the wave function. Normalization of wave function.

Unit-II: QUANTUM MECHANICS-2 **[Lecture-15]**

Time independent Schrodinger equation: One dimensional potential well and barrier. Boundary conditions. Bound and unbound states. Reflection and transmission coefficients for a rectangular barrier in one dimension. Explanation of alpha decay. Quantum phenomenon of tunneling. Free particle in one-dimensional box, eigen functions and eigen values of a free particle. One-dimensional simple harmonic oscillator, energy eigenvalues from Hermite differential equation, wave function for ground state. Particle in a spherically symmetric potential. Rigid rotator.

Unit-III: ATOMIC SPECTROSCOPY [Lecture-15]

Atoms in electric and magnetic fields: Quantum numbers, Bohr model and selection rules. Stern-Gerlach experiment. Spin as an intrinsic quantum number. Incompatibility of spin with classical ideas. Orbital angular momentum. Fine structure. Total angular momentum. Pauli exclusion principle. Many particles in one dimensional box. Symmetric and anti-symmetric wave functions. Atomic shell model. Spectral notations for atomic states. Spin-orbit coupling, L-S and J-J coupling. Zeeman effect. Continuous and characteristic X-rays. Mossley's law.

Unit-IV: MOLECULAR SPECTROSCOPY [Lecture-15]

Spectra: Various types of spectra. Rotational spectra. Intensity of spectral lines and determination of bond distance of diatomic molecules. Isotope effect. Vibrational energies of diatomic molecules. Zero point energy. Anharmonicity. Morse potential. Raman effect, Stokes and anti-Stokes lines and their intensity difference. Electronic spectra. Born-Oppenheimer approximation. Frank- Condon principle, singlet and triplet states. Fluorescence and phosphorescence.

Unit-V: NUCLEAR PHYSICS [Lecture-15]

Basic properties of nucleus: Shape, Size, Mass and Charge of the nucleus. Stability of the nucleus and Binding energy. Alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law. Nature of beta ray spectra. The neutrino. Energy levels and decay schemes. Positron emission and electron capture. Selection rules. Beta absorption and range of beta particles. Kurie plot. Nuclear reactions, pair production. Q-values and threshold of nuclear reactions. Nuclear reaction cross-sections. Examples of different types of reactions and their characteristics. Compound nucleus, Bohr's postulate of compound nuclear reaction, Semi empirical mass formula, Shell model, Liquid drop model, Nuclear fission and fusion (concepts).

References:

1. Quantum Mechanics: V.Devanathan, Narosa Publishing House, New Delhi, 2005
2. Quantum Mechanics: B.H. Bransden, Pearson Education, Singapore, 2005
3. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, John Wiley and Sons. Ltd, 2009
4. Physics of Atoms and Molecules: B.H. Bransden and C.J.Joachaim, Pearson Education, Singapore, 2003
5. Fundamental of Molecular Spectroscopy: C.M.Banwell and M. McCash, McGraw Hill.
6. Introduction to Atomic Physics: H.E.White
7. Quantum Mechanics: Schaums Outlines, Y.Peleg, R.Pnini, E.Zaarur, E.Hecht.

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Department of Physics

B. **Sc. III Year**

Paper II: Solid State Physics and Devices

Max. Marks: 40

Pass Marks: 13

Course Outcome

The students are expected to acquire the knowledge of the following:

- Idea about crystalline and amorphous substances, reciprocal lattice, concept of Brillouin zones and diffraction of X-rays by crystalline materials.
- Lattice vibrations, phonons and theories of specific heat of solids.
- Different types of magnetism, hysteresis loops and energy loss.
- Band theory of solids, Basics of Semiconductor and two terminal devices and their applications
- Transistors and FET; configuration in different mode and mode of operation, h-parameter and their application in oscillators and amplifiers.
- Introduction of nanomaterials and nanotechnology, 3D, 2D, 1D and 0D, nanostructured materials and their synthesis techniques, properties and applications.
- Experiments related to theory course.

Unit-I: SOLID STATE PHYSICS-1 [Lecture-15]

Crystal Structure and bonding: Crystalline and amorphous solids. Translational symmetry. Lattice and basis. Unit cell. Reciprocal lattice. Fundamental types of lattices (Bravias Lattice). Miller indices Lattice planes. Simple cubic. Face centered cubic. Body centered cubic lattices. Laue and Bragg's equations. Determination of crystal structure with X-rays, X-ray spectrometer. Ionic, covalent, metallic, van der Waals and hydrogen bonding. Band theory of solids. Periodic potential and Bloch theorem. Kronig-Penny model (Qualitative).

Unit-II: SOLID STATE PHYSICS-2 [Lecture-15]

Lattice structure and properties: Dulong Petit, Einstein and Debye theories of specific heats of solids. Elastic and atomic force constants. Dynamics of a chain of similar atoms and chain of two types of atoms. Optical and acoustic modes. Electrical resistivity. Specific heat of electron. Wiedemann-Franz law. Hall effect. Response of substances in magnetic field, dia-, para- and ferromagnetic materials. Classical Langevin theory of dia and paramagnetic domains. Curie's law. Weiss' theory of ferromagnetism and ferromagnetic domains. Discussion of BH hysteresis.

Unit-III: SEMICONDUCTOR DEVICES-1 [Lecture-15]

Electronic devices: Types of Semiconductors (p and n). Formation of Energy Bands, Energy level diagram. Conductivity and mobility. Junction formation, Barrier formation in p-n junction diode. Current flow mechanism in forward and reverse biased diode (recombination), drift and saturation of drift velocity. Derivation of mathematical equations for barrier potential, barrier width. Single p-n junction device (physical explanation, current voltage characteristics and one or two applications). Two terminal devices. Rectification. Zener diode. Photo diode. Light emitting diode. Solar cell. Three terminal devices. Junction field effect transistor (JFET). Two junction devices. Transistors as **p-n-p** and **n-p-n**. Physical mechanism of current flow and characteristics of transistor.

Unit-IV: SEMICONDUCTOR DEVICES-2 [Lecture-15]

Amplifiers (only bipolar junction transistor). CB, CE and CC configurations. Single stage CE amplifier (biasing and stabilization circuits), Q-point, equivalent circuit, input impedance, output impedance, voltage and current gain. Class A, B, C amplifiers (definitions). RC coupled amplifiers (frequency response). Class B push-pull amplifier. Feedback amplifiers. Voltage feedback and current feedback. Effect of negative voltage series feedback on input impedance. Output impedance and gain. Stability, distortion and noise. Principle of an Oscillator, Barkhausen criterion, Colpitts, RC phase shift oscillators. Basic concepts of amplitude, frequency and phase modulations and demodulation.

Unit-V: NANO MATERIALS [Lecture-15]

Nanostructures: Introduction to nanotechnology, structure and size dependent properties. 3D, 2D, 1D, 0D nanostructure materials and their density of states, Surface and Interface effects. Modelling of quantum size effect. Synthesis of nanoparticles - Bottom Up and top Down approach, Wet Chemical Method. Nanolithography. Metal and Semiconducting nanomaterials. Essential differences in structural and properties of bulk and nano materials (qualitative description). Naturally occurring nano crystals. Applications of nanomaterials.

References:

1. Introduction to Solid State Physics: C.Kittel, VIII Edition, John Wiley and Sons, New York, 2005.
2. Intermediate Quantum Theory of Crystalline Solids: A.O.E. Animalu, Prentic-Hall of India Pvt. Ltd., New Delhi, 1977
3. Solid State Electronic Devices: B.G.Streetman, II Edition , Prentic-Hall of India Pvt. Ltd., New Delhi
4. Microelectronics: J.Millman and A. Grabel, McGraw Hill, NewYork
5. The Physics and Chemistry of Nanosolides: Frank J. Owens and Charles P. Pooles Jr., Wiley Inter Science, 2008
6. Physics of Low Dimensional Semiconductors: An introduction, J.H. Davies, Cambridge University Press, UK, 1998
7. Electronic Fundamental and applications, J.D. Ryder, Prentic Hall, India

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B.Sc. III Year (2019-2020)

List of Physics Practical

1. To determine the value of Planck's constant "h" by solar cell.
2. To determine the energy band gap of a semiconductor by Regnault's apparatus.
3. To plot the characteristic curve of PN Junction Diode in Forward bias condition.
4. To plot the characteristic curve of a Zener Diode in forward and reverse bias condition.
5. To plot the characteristic curve of a Tunnel Diode.
6. To plot the characteristic curve of different colour LEDs.
7. To study the characteristic curve of JFET.
8. To study the characteristic curves of a transistor in CE mode.
9. To study the characteristic curves of a transistor in CB mode.
10. To study the half wave, full wave and bridge rectifier and the effect of different filter circuits on ac-ripple factor.
11. To study the frequency response curve of single stage RC-coupled amplifier and to calculate the band width.
12. To determine energy band gap of germanium crystal using four probe method.
13. To study Hartley oscillator/ Colpitts oscillator.
14. To study RC phase shift oscillator.
15. To study Hall Effect.
16. To study Hysteresis Loss.
17. To study modulation /demodulation.
18. To determine the capacitance by Schering Bridge.
19. To determine the unknown frequency by Lissajous Figures.