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PG CBCS

M.SC. Semester-I Examination, 2021

DEPARTMENT OF PHYSICS

PAPER: PHS 102

(QUANTUM MECHANICS – I & SOLID STATE -I)

Full Marks: 40 **Time: 2 Hours**

Write the answer for each unit in separate sheet

PHS 102.1 (Quantum Mechanics – I)

Answer any TWO questions of the following: **2X10=20**

1. State the essential conditions of an oscillator to show the quantum properties than classical regime in one dimension? What properties are different of a quantum oscillator with classical one inside a finite potential barrier? Find the number of bound states for a particle of mass 2200 electron mass in a square well potential of depth 70 Mev and radius 1.42 fm. (2+5+3)
2. (a) A particle of mass m is trapped in a hollow sphere of radius R with impenetrable walls. Obtain an expression for the force exerted on the walls of the sphere by the particle in the ground state.
   (b) Taking the ground state Eigen function $\psi(r) = \frac{1}{\sqrt{\pi a_o^3}} e^{-r/a}$ Show that for an electron in the ground state of the hydrogen atom the momentum-probability distribution is given by
   $$\frac{8}{\pi^2} \frac{\frac{\hbar}{a_o}^5}{(p^2+\frac{\hbar}{a_o}^2)^4}$$ (4+6)
3. (a) A particle of mass m moves in a spherically symmetric potential U = Mr, where M is a positive constant. Find the ground state energy.
   (b) Show that, if the Hamiltonian H of a system does not depend explicitly on time. The ket $|\psi(t)\rangle$ varies with time according to $|\psi(t)\rangle = \exp(-\frac{iHt}{\hbar})|\psi(0)\rangle$ (4+6)
4. (a) Show that the most probable magnitude of the momentum of the electron is $\frac{\hbar}{\sqrt{3}a_o}$ and its mean value is $\frac{8\hbar}{3\pi a_o}$ where a_o is Bohr radius.
   (b) What operator may be used to distinguish between (i) e^{ikx} and e^{-ikx} (ii) sin(ax) and cos(ax)?
   (c) For a square wave packet
   $$\psi(x) = Ae^{ikx} \quad \text{for } |x| \leq a$$
   $$= 0 \quad \text{for } |x| > a$$
   Find the equation of momentum-function. (5+2+3)

5. Deduce transmission probability of a particle posses kinetic energy E inside a uniform square well potential barrier V. Using above solution deduce nuclear disintegration Geiger–Nuttall formula. (5+5)

PHS 102.2 (Solid State -I)

Answer any TWO questions of the following: 2X10=20

1. Describe in details the symmetry elements associated with point group. Explain also the two new symmetry elements associated with space group. Show the stereogram and matrix representation of point group 222. (4+4+2)
2. Derive the Laue equation considering the scattering of X-rays from a crystal. Express Laue equation also involving reciprocal lattice vector. (9+1)
3. Derive the dispersion relation for linear one dimensional diatomic lattice in vibration. Explain optical and acoustical branch. Also Find their frequency at k=0 and k=π/a. Assume nearest neighbour distance is a/2. (5+2+3)
4. Express structure factor in terms of fractional coordinate. Find the structure factor of FCC crystal and hence find the condition for systematic absence. Explain Debye Waller effect. (2+4+4)
5. Describe in details the essential features of Kronig Penney Model. E-k relation in a particular solid is given by $E = AK^2+BK^3$, where A & B are positive constants. Find the wave vectors for which electron group velocity is zero. (8+2)

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