2021
(JUNE)

PHYSICS
HONOURS

PHY-308

EIGHT PAPER
(Quantum Mechanics)
Theory

Full Marks: 50
The figures in the margin indicates full marks for the questions
Answer all the questions.

1. a) Give a precise statements bringing out the difference between Planck's hypothesis and Einstein's hypothesis about radiation.

   b) What makes the classical inadequancy in the study of photoelectric effect? How can it be removed by Einstein?

   c) Show that in order to associate de Broglie wave with the propagation of photons, photons must travel with the speed of light c and their rest mass must be zero. 2+3+2+3=10

2. a) Develop the equation of motion,
   $\frac{d}{dt} < \mathrm{A} > = \frac{1}{i\hbar} < [A, H] >$,
   where A is a dynamical variable which does not have explicit time dependence and H , the Hamiltonian of motion. 10

Or

   b) Deduce the Eherenfest's theorem,
   $\frac{d}{dt} < \mathrm{x} > = \frac{1}{m} < p >$,
   where all quantities have their usual physical meanings. 7

   c) Show that in one dimension, the operator $\hat{T} = \frac{\hbar^2}{2m}\frac{d^2}{dx^2}$ is Hermitian. 3

3. a) What are stationary states? Show that if a particle is in a stationary state at a given time, it is always remain in a stationary state. 3

   b) A potential is defined as
   $\mathrm{V}(x) = 0$, for $0 \leq x \leq a$
   $= \infty$' for $x > a$ *and* $x < 0$
   Solve the Schrodinger wave equation for the system and also develop the energy eigenvalues. 7

Or

   c) Write down the Schrodinger wave equation for the motion of a free particle confined along a particular direction. Obtain the energy eigenstate and energy eigenvalue for the system of motion. 1+6=7

4. a) A free particle travelling in the positive x – direction is incident on a potential step at x =0 , given by
   $V(x) = 0$ for $x < 0$
   $= V_0$ for $x > 0$
   If the energy of the particle E < V_0 , determine the reflection and transmission coefficients and also deduce the condition for having quantum tunnelling effect. 5+5+1=11

Or

b) Calculate $<x^2>$ and $<p^2>$ for a linear harmonic oscillator at the level of n^{th} state and also deduce that $<T> = <V>$, where all the quantities have their usual meanings. 4+5+2=11

5. Answer any three of the following: 3x3=9

a) Neglecting electron spin degeneracy, show that the hydrogen atom energy levels are n^2 – fold degeneracy, with n >1.

b) Show that the most probable distance of electron from the nucleus in the ground state of hydrogen atom is equal to Bohr's radius.

c) Calculate the average distance from electron to nucleus at the level of ground state,
$\psi_{100}(r) = \frac{1}{\sqrt{\pi a^3}} e^{-\frac{r}{a_0}}$, where a_0 is the Bohr's radius.

d) Use the radial Schrodinger equation for the hydrogen atom to find the ground state energy E_1, given that the ground state radial wavefunction is
$R10\ (r) = A\, e^{-\frac{r}{a_0}}$, where $a_0 = \frac{\hbar^2}{\mu e^2}$, the Bohr's radius and A is constant and all other quantities have their usual meanings.

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2021
(JUNE)

PHYSICS
HONOURS

PHY-309

NINTH PAPER
(Physics of Materials)
Theory

Full Marks: 50
The figures in the margin indicates full marks for the questions
Answer all the questions.

1. Define crystal lattice and basis. Describe the seven systems of crystals to show that there are fourteen Bravais lattices in three dimensions. 2+8=10

Or

Show that for a simple cubic lattice, $d_{100}: d_{110}: d_{111} = \sqrt{6}:\sqrt{3}:\sqrt{2}$ where d is the distance between consecutive parallel planes. What is reciprocal lattice? Show that f.c.c. lattice is reciprocal lattice of b.c.c. lattice. 5+1+4=10

2. Derive the expressions for electrical conductivity and thermal conductivity on the basis of classical free electron theory. Obtain Wiedemann- Franz law. 8+2=10

Or

State Bloch Theorem and show how Kronig-Penny model leads to the formation of energy bands for an electron in a periodic potential. 2+8=10

3. Derive an expression for the lattice specific heat of a solid based on Einstein's model and discuss the low temperature and high temperature behaviour of this specific heat. 7+3=10

Or

Obtain the dispersion relation for a one-dimensional diatomic lattice. Illustrate with a proper dispersion curve, the occurrence of acoustical and optical branches and give a brief discussion. 7+3=10

4. Give an account of the Weiss theory of ferromagnetism and derive the Curie-Weiss law. 10

Or

Obtain Curie's law of paramagnetism from Langevin's theory. 10

5. Derive the London's equations and obtain an expression of penetration depth. 8+2=10

Or

What are nanomaterials? State three main applications of nanomaterials. What are quantum wells, wires and dots? Mention the four types of nanomaterials. 2+3+3+2=10

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