Exam.Code:0905
Sub. Code: 6645

1108

B.E., (Biotechnology)
First Semester
APH-103: Quantum and Statistical Physics
(Common with IT and CSE)

Time allowed: 3 Hours **Max. Marks: 50**

NOTE: Attempt five questions in all, including Question No. I which is compulsory and selecting two questions from each Part.

x-x-x

Q1. Attempt any five parts of the following:

(a) Why gravitational shift is not apparent for most of the stars? (2)

(b) Define occupancy of states for electrons, whose energies are less than or greater than the Fermi energy. (2)

(c) What bearing would you think the uncertainty principle has on the zero point energy of a harmonic oscillator? (2)

(d) What is the utility of normalization of a wave function? (2)

(e) Calculate the number of different arrangements of 6 bosons among 4 cells of equal a priori probability? (2)

(f) Show that the pair production cannot occur in free space. (2)

(g) Why a particle trapped in a potential box cannot be at rest? (2)

Part A

Q2. (a) What is the main drawback of Galilean transformation and how it was over come in Lorentz transformations? Obtain Lorentz transformation laws for position and time coordinates. (5)

(b) What is the aim and the conclusion of Michelsen-Morely experiment? (2)

(c) Prove that $\frac{1}{2}\gamma mv^2$ does not equal the kinetic energy of a particle moving at relativistic speed? (3)

Q3. (a) Why does the (relativistic) mass of an object increase when its speed approaches to that of light? Cite an experiment which supports this phenomenon. (6)

(b) X-rays of wavelength 10 pm are scattered from a target. (i) Find the wavelength of x-rays scattered through 45°. (ii) Find the maximum wavelength present in scattered x-rays. (iii) Find the maximum kinetic energy of the recoil electron. (4)

Q4. (a) Cite the experiment which demonstrated the wave nature of the electron, confirming the de Broglie hypothesis of wave character of particles. (6)

(b) What is Born's interpretation of wave function? What are the essential conditions that a wave function must fulfil. (4)

P.T.O.

Part B

Q5. (a) A particle is confined to a one - dimensional box on the x - axis between x = 0 and x = L. The potential height of the walls of the box is infinite. Find the normalized wave function of the particle and discrete energy states. (6)

(b) Find the expectation value $\langle x \rangle$ of the position of a particle trapped in a box L wide. (4)

Q6. (a) Find the allowed energies of the harmonic oscillator in quantum mechanics in terms of the quantum number n, Planck's constant and the frequency of the corresponding classical oscillator. Sketch the energy eigen functions (i.e. spatial wavefunctions) of the n= 0 and n= 1 states. (6)

(b) Prove that average value of $\langle \frac{1}{r} \rangle$ for a 1s electron in hydrogen atom is $\langle \frac{1}{a_0} \rangle$. a_0 is Bohr Radius and wave function for 1s electron is $\Psi = \frac{e^{\frac{-r}{a_0}}}{\sqrt{\pi}\, a_0^{\frac{3}{2}}}$. (4)

Q6. (a) Discuss the Stern-Gerlach Experiment in detail. What did it demonstrate and how did it work? Why inhomogeneous magnetic field was applied in this experiment? (5)

(b) Compare Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. (5)

Q7. (a) Show that the average kinetic energy of a three dimensional gas of N free electrons at 0°K is $\overline{E_0} = \frac{3}{5} N E_F$. (5)

(b) Discuss the phenomenon of thermionic emission in metals. Obtain Richardson – Dushman equation. (5)

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