B.Sc.(Honours) Examination, 2019

Semester - VI

Physics (Honours)

Paper: BPC-61

(Elementary Quantum Mechanics)

Time: Three Hours **Full Marks: 40**

Questions are of value as indicated in the margin.

Answer ***Question No. 1*** and ***any three*** from rest of the questions.

1. Answer any *five* questions. **2 x 5**
   a. In a Compoton scattering experiment an X-ray beam of wavelength 0.015 nm incident on a graphite plate. If the beam scattered at an angle $\pi/2$, find the kintetic energy of the emitted electron.
   b. If ψ_1 and ψ_2 are two solutions of a Schrödinger equation then show that their linear combination is also a solution of the same equation.
   c. In a proton-proton collider experiment if the uncertainty in measuring the velocity of the proton is 4 Km/s, find the uncertainty in measuring its position.
   d. Show that the momentum operator p_x is an Hermitian operator.
   e. Obtain the commutation relation between x and its conjugate momentum p_x.
   f. What do you mean by compatible observable? Show that L_z and L^2 are two compatible observables.
   g. What is the significance of Stern-Gerlach experiment?
   h. Write down the Schwartz inequality and generalized uncertainty principle.

2. Derive an expression of the Rayleigh-Jeans formula for the blackbody radiation. What is the shortcoming of this formula. Explain how Planck's postulate can explain the observed blackbody spectrum. **5+2+3**

3. Discuss the quantum theory of photoelectric effect. Using this theory how can we explain the existence of cutoff frequency? Define stopping potential. What will be the work function of a metal if the cutoff frequency in an experiment is obtained as 5.6×10^{14} Hz. **4+2+1+3**

4. Briefly discuss the Davisson-Germer experiment and Young's double slit experiment. **5+5**

5. Suppose the energy state of a free particle of mass m is given by $A\ cos(\pi x/a)e^{-iEt/\hbar}$ between $-a/2 < x < a/2$ and zero elsewhere. What is the energy of the particle? Calculate the expectation value of x and p_x. What are the required properties of a wavefunction? **3+4+3**

6. Suppose a potential V(x) is defined as V_0 for $x > 0$ region and it is zero otherwise. Assume a particle of mass m and total energy E ($<V_0$) is moving towards the point $x = 0$ from the region $x < 0$. Obtain the reflection coefficient. What can we comment about the wave function in the classically excluded region. **8+2**

7. Show that in case of Hydrogen atom problem $[H, \mathbf{L}] = 0$. Obtain the commutations $[L_+, L_-]$ and $[L_x, L_y]$. Use algebraic method to obtain the eigenvalues of the L^2 and L_z operators. **2+2+6**

Useful Information:

$c = 3 \times 10^8$ m/s, $h = 6.62 \times 10^{-34}$ J-s, $m_e = 9.1 \times 10^{-31}$ kg, $m_p = 1.67 \times 10^{-27}$ kg and 1 nm = 10^{-9} m.