B.Sc. 5th Semester (Honours) Examination, 2019-20

PHYSICS

Course ID : 52411 **Course Code : SH/PHS/501/C-11**

Course Title : Quantum Mechanics and Applications

Time: 1 Hour 15 Minutes **Full Marks: 25**

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

Section-I

1. Answer *any five* questions: 1×5=5

(a) What is the ionization energy of a hydrogen atom if the atom is in its first excited state?

(b) State Hund's rule.

(c) Show that the relation $[L_x, L_y] = i\hbar L_z$ is valid for the x, y and z components of L.

(d) What are the requirements that a function should obey to describe properly the state of a particle?

(e) What is the physical significance of normalization of wave function in Quantum Mechanics?

(f) Write down the expression of Larmour frequency.

(g) Name two experimental observations which support the existence of spin of electrons.

(h) Write down the expression of probability current density in 3D.

Section-II

Answer *any two* questions: 5×2=10

2. What do you mean by stationary states? Starting from the time-dependent Schrödinger equation, find the time-independent Schrödinger equation that is satisfied by the wave functions for stationary states.

3. Considering the Gaussian wave function in momentum space $\phi(P_x) = e^{-(P_x - P_0)^2/r^2}$. Establish the position momentum uncertainty principle. (The symbols have their usual meaning). 5

4. Determine the orbital magnetic moment of an electron moving in a circular orbit of radius r about a proton. Calculate the frequency at which an electron's orbital magnetic moment precesses in a magnetic field $\vec{B}$. 2+3=5

5. Given the normalized eigen function for the ground state of hydrogen atom is $\psi_0 = \frac{1}{\sqrt{\pi a_o^3}} e^{-r/a_0}$,

where a_0 is the Bohr radius.

Show that the electron density in the hydrogen is maximum at $r = a_0$. 5

Section-III

Answer *any one* of the following questions: 10×1=10

6. What are the normal and anomalous Zeeman effect? Give the theory of Zeeman effect when the atom is place in weak magnetic field and explain the results in the context of Na D-lines.

What happens if the magnetic field is increased to a high value? 1+(6+2)+1=10

7. Show that an appropriate boundary condition on the solution of the Schrödinger equation for the linear harmonic oscillator leads to the discrete spectrum of its energy.

Find the probability of finding the linear harmonic oscillator within classical limits. Given the ground state wave function of the linear harmonic oscillator is

$\psi(x) = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} exp\left[-\frac{1}{2}\left(\frac{m\omega}{\hbar}\right)x^2\right]$, where the symbols have their usual meanings. 7+3=10

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