B.Sc. 5th Semester (Honours) Examination, 2020-21

PHYSICS

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

Course Title: Quantum Mechanics & Applications

Time: 1 hour15 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 (05)*** of the following questions 5 X 1 = 5

a) What do you mean by expectation value?
b) Where do we apply L-S coupling scheme?
c) What is the wavelength of the emitted X-ray when an electron of energy 100 KeV strikes the target?
d) Estimate the minimum uncertainty in the momentum of an electron confined in a box of length 1µm.
e) Spin or orbital motion of electron, which one has greater contribution in atomic magnetism?
f) What is the de Broglie wavelength of a non-relativistic particle of mass m moving with kinetic energy W?
g) What do you mean by space quantisation?
h) Define probability current density.

Section-II

2. Answer any ***two (02)*** of the following questions 5 × 2 =10

a) Evaluate Lande g factor of the $^2P_{3/2}$ level of sodium atom. How many distinct levels will appear when the sodium atom is subjected to an external weak magnetic field? 2+3

b) What is Larmour's precession? Derive the equation for frequency of Larmour's precession. 2+3

c) State and explain Pauli's exclusion principle. Use it to have the number of maximum electrons for a particular principal quantum number. 2+3

d) The potential energy of a simple harmonic oscillator of mass m, oscillating with angular frequency ω, is $V(x) = \frac{1}{2} m\omega^2 x^2$. The eigen function of the Hamiltonian operator for the

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ground state of the oscillator is given by the equation: $\varphi_0 = \left(\frac{2\pi m\omega}{\pi h}\right)^{\frac{1}{4}} \; e^{-\alpha^2 x^2/2}$ where $\alpha = \sqrt{\frac{2\pi m\omega}{h}}$. Calculate the energy eigen value in the ground state. 5

Section-III

3. Answer any ***one (01)*** of the following questions 10 × 1 =10

a) Discuss the results of the Frank-Hertz experiment and explain how it confirmed the concept of discrete stationary states of atoms. The wave function of a particle moving in one dimension is given to be

$$\varphi(x) = \sqrt{\frac{15}{2}}\, A\,(a^2 - x^2) \text{ for } -a \le x \le a$$

$$= 0 \text{ for } |x| > a$$

Find the value of A that will normalise $\varphi(x)$ and calculate the expectation values of x and p.

5+2+3

b) Derive a continuity equation from the time dependent Schrödinger equation of a particle moving in a real potential. Give the physical interpretation of the continuity equation you derived. Obtain the expression of magnetic moment of an electron due to its orbital motion and find out the value of Bohr magneton. 4+1+3+2
