A–086

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MSCPH–503

M.Sc. PHYSICS (MSCPH)

(Quantum Mechanics)

1st Semester Examination, 2024 (June)

Time : 2:00 Hrs. Max. Marks : 70

Note* :–** This paper is of Seventy (70) marks divided into Two (02) Sections 'A' and 'B'. Attempt the questions contained in these Sections according to the detailed instructions given therein. ***Candidates should limit their answers to the questions on the given answer sheet. No additional (B) answer sheet will be issued.

Section–A

(Long Answer Type Questions) 2×19=38

***Note* :–** Section 'A' contains Five (05) Long-answer type questions of Nineteen (19) marks each. Learners are required to answer any *two* (02) questions only.

1. Describe Planck's law of radiation and state the conditions when the Planck's formula reduces to Wein's law and Rayleigh-Jean's law of black body radiation.

2. Discuss the Schrodinger, the Heisenberg and the interaction representation for describing the dynamical behavior of a system.

3. Write short notes on the following :

   (a) Pauli's exclusion principle

   (b) Density operator

   (c) Density matrix

   (d) Symmetric wave function

   (e) Anti-symmetric wave function

4. Deduce the commutation relation for the components L_x, L_y, L_z of the orbital angular momentum and show that all the three components commute with $L^2 = L_x^2 + L_y^2 + L_z^2$. Derive eigen values of L^2 and L_z.

5. Use the Born approximation to obtain the differential scattering cross section for a spinless particle of energy E by potential given by :

$$V(r) = -V_0 \text{ for } r < a$$

$$V(r) = 0 \text{ for } r > a$$

Section–B

(Short Answer Type Questions) 4×8=32

***Note* :–** Section 'B' contains Eight (08) Short-answer type questions of Eight (08) marks each. Learners are required to answer any *four* (04) questions only.

1. Find the energy of the neutron in units of electron – volt whose De Broglie wavelength is 1 A^0. Given mass of neutron = 1.674×10^{-27} kg, Planck's constant h = 6.60×10^{-34} Joule-sec.

2. Calculate the expectation value of P^2 for the wave function :

$$\varphi(x) = \sqrt{\frac{2}{L}} \sin \frac{\pi x}{L} \quad \text{in the region } 0 < x < L$$

and $\varphi(x) = 0$ for $|x| > L$

3. Derive the Schrödinger relation for a linear harmonic oscillator and obtain its eigen values and eigen functions.

4. Describe the basic features of operator formalism in quantum mechanics and prove Ehrenfest's theorem.

5. Show by an example how operators are expressed into a matrix form. Show that a Hermitian operator can be expressed as a diagonal matrix.

6. Obtain Clebsch Gordan coefficient when two angular momenta $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$ are coupled.

7. Calculate the energy of the ground state of Helium atom corrected to first order. Suggest further improvements in the calculation.

8. What is quantum mechanical tunneling. Derive an expression for decay constant in connection with Gamow's theory of α-decay.

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