S-480

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MPHY-504

Quantum Mechanics

M.Sc. Physics (MSCPHY)

1st Semester Examination, 2022 (Dec.)

Time : 2 Hours] **[Max. Marks : 35**

Note : This paper is of Thirty Five (35) marks divided into two (02) Sections A and B. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION–A
(Long Answer Type Questions)

Note : Section 'A' contains Five (05) long answer type questions of Nine and Half (9½) marks each. Learners are required to answer any Two (02) questions only. (2×9½=19)

1. Write down the Schroedinger wave equation for a particle in a box. Solve it to obtain eigen function and show that the eigen values are discrete.

2. Explain how Dirac arrived at a linear equation starting from the relation

$$E^2 = c^2p^2 + m^2c^4$$

Show that a particle obeying the Dirac equation is endowed with a spin momentum.

3. 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.

4. State and prove the Variational principle for obtaining approximate energies. Use it to find the ground state energy of hydrogen atom.

5. Develop the Klein-Gordon equation for a spin zero particle. Construct the corresponding continuity equation and discuss its non-relativistic limit.

SECTION–B
(Short Answer Type Questions)

Note : Section 'B' contains Eight (08) short answer type questions of Four (04) marks each. Learners are required to answer any Four (04) questions only. (4×4=16)

1. Obtain Schroedinger's time dependent wave equation and show $H\varphi = E\varphi$.

2. What is the physical significance of wave function?

3. Discuss the parity of the eigen functions and zero-point energy of a linear harmonic oscillator.

4. What are the characteristics of hydrogen atom obtained after solving Schroedinger equation?

5. What are Clebsch-Gordan Coefficients? Write down their properties.

6. For Pauli spin matrices, prove that

$$\vec{\sigma} \times \vec{\sigma} = 2i\vec{\sigma}$$

7. What is the value of ground state energy of He-atom according to perturbation theory?

8. Apply the perturbation theory to evaluate the first order energy shift in the ground state of a linear harmonic oscillator by a small perturbing potential CX^4 in the Hamiltonian.
