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Total Pages : 4

235501

December, 2019

B.Sc. (Physics)-V SEMESTER

Quantum Mechanics & Applications (BPH-501)

Time : 3 Hours] [Max. Marks : 75

Instructions :

1. *It is compulsory to answer all the questions (1.5 marks each) of Part-A in short.*
2. *Answer any four questions from Part-B in detail.*
3. *Different sub-parts of a question are to be attempted adjacent to each other.*

PART - A

1. (a) Consider a one dimensional particle which is confined within the region $0 \leq x \leq a$ and whose wave function is

$$\psi(x,t) = \sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}$$

Calculate the probability of finding the particle in the interval $a/4 \leq x \leq 3a/4$. (1.5)

(b) State the conditions for physical acceptability of wave function. (1.5)

(c) The wave function for a particle confined in a one dimensional box of length L is given by

$$\psi(x) = A \sin (n\pi x/L)$$

Normalize the wave function. (1.5)

(d) What do you mean by Hamiltonian operator. Discuss its physical significance. (1.5)

(e) What is stationary in stationary states of time independent Schrodinger equation. (1.5)

(f) Write an expression for any arbitrary function as a linear combination of energy eigen functions. (1.5)

(g) What are the conditions of continuity of a wave function at boundary. (1.5)

(h) Explain the emergence of discrete energy levels in the solution of Schrodinger wave equation. (1.5)

(i) Deduce an expression for time independent Schrodinger equation in spherical polar co-ordinates. (1.5)

(j) What are Pauli spin matrices. (1.5)

PART - B

2. (a) Obtain the expression for probability current density for a particle. (7)

(b) Prove the orthogonality of an arbitrary eigen function. (4)

(c) Prove the following commutation relations:

$$[x, p_z] = 0$$

$$[x, y] = 0$$

$$[z, p_z] = i\hbar.$$ (4)

3. (a) Derive Schrodinger time dependent wave equation. (5)

(b) Deduce the general solution of time independent Schrodinger wave equation and show that the general solution forms a linear combination of stationary states. (10)

4. Explain the application of Schrodinger time independent wave equation to spread of Gaussian wave-packet for a free particle in one dimension. (15)

5. (a) Discuss the role of parity operator in bound states. (5)

(b) Show that the particle in one dimensional infinite square well have discrete energy states. Plot first three eigen functions. (10)

6. (a) What are energy levels and energy functions of a simple harmonic oscillator. Give the normalized wave function of simple harmonic oscillator. (8)

(b) Illustrate the use of separation of variables method for the general solution of time dependent Schrodinger equation for a spin less particle. (7)

7. (a) Derive the solution of radial wave equation for Hydrogen atom using Frobenius method. (7)

(b) Describe angular momentum operator. Discuss quantum numbers and their physical significance. (8)
