Sr. No...321505

December 2023

B.Sc. (Physics) - V SEMESTER (Re-Appear)

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.*
4. ~~*Any other specific instructions*~~

PART -A

Q1 (a) Derive Schrodinger time dependent wave equation. (1.5)

(b) Discuss the physical significance of wave function. (1.5)

(c) What do you mean by linearity and superposition principles for a wave function. Explain with a suitable example. (1.5)

(d) What do you mean stationary states? (1.5)

(e) Explain Heisenberg's uncertainty principle. (1.5)

(f) Explain the emergence of discrete energy levels with application of boundary conditions. (1.5)

(g) What is zero-point energy of a simple harmonic oscillator? (1.5)

(h) Express Schrodinger equation in spherical polar coordinates. (1.5)

(i) Write down the components of orbital angular momentum in terms of cartesian coordinates. (1.5)

(j) State and prove any one property of Pauli spin matrices. (1.5)

PART -B

Q2 (a) Express the most general solution of the time dependent Schrodinger equation in terms of linear combination of stationary states. Verify that a linear combination of stationary states may not be a stationary state. (10)

(b) What do you mean by probability density and probability current densities in three dimensions. Derive equation of continuity between these quantities. (5)

Q3 (a) A particle is represented (At time t = 0) by the wave function (5)

$$\psi(x,0) = \begin{cases} \sqrt{\dfrac{15}{16a^5}}(a^2 - x^2), & if \quad -a \le x \le +a \\ 0 & otherwise. \end{cases}$$

If the value of normalization constant A is given by $A = \sqrt{\frac{15}{16a^5}}$, determine the expectation value of p^2

321505/20/111/429

(b) Explain Fourier transforms and its application in position space and momentum space wave functions. How, the probability densities in position space and momentum space may be regarded as equivalent, Explain. (10)

Q4 The Gaussian wave packet for a free particle is given by the wave function $\varphi(k) = Ae^{\frac{-a^2}{4}(k-k_0)^2}$. Derive an expression for normalized wave function in position space representation. (15)
(Given that $\int_{-\infty}^{\infty} e^{\;x^2/a^2}\,dx = a\sqrt{\pi}$ and $\int_{-\infty}^{\infty} e^{-ax^2/+bx}\,dx = \frac{\sqrt{\pi}}{a}e^{b^2/4a}$

Q5 (a) Discuss the significance of type of potential in continuity of wave function. Also discuss the importance of boundary conditions. (5)

(b) Derive an expression to determine Transmission coefficient (T) in case of a particle moving in positive x direction, strikes at a finite potential barrier of width "a". (10)

Q6 (a) Derive an expression to determine the energy eigen values for simple harmonic oscillator. (10)

(b) Illustrate the use of separation of variables method for the general solution of time independent Schrodinger equation. (5)

Q7 Derive an expression to evaluate energy in the first excited state of Hydrogen atom solving radial wave equation using power series method. (15)

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