D 50730 (Pages : 4) Name.....

Reg. No.....

FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2013

(UG—CCSS)

Physics—Core Course

PH 5B 10 / AP 5B 12—QUANTUM MECHANICS

(Common for Applied Physics)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*

1. Matter waves

   (a) Are longitudinal. (b) Are electromagnetic.

   (c) Always travel with speed of light. (d) Show diffraction.

2. According to Schrödinger, a particle is equivalent to a :

   (a) Single wave. (b) Wave-packet.

   (c) Light wave. (d) Cannot behave as wave.

3. The uncertainty relation cannot hold for the following pairs :

   (a) Position and momentum. (b) Energy and time.

   (c) Linear momentum and angle. (d) Angular momentum and angle.

4. A particle possesses discrete energy levels :

   (a) In free space. (b) In a box of rigid walls.

   (c) Both (*a*) and (*b*). (d) Neither (*a*) nor (*b*).

5. The allowed energy valves of a particle in box of length L are given by :

   (a) $\frac{n^2 \pi^2 \hbar^2}{mL^2}$. (b) $\frac{n^2 \pi^2 \hbar^2}{2mL^2}$.

   (c) $\frac{\pi^2 \hbar^2}{2mL^2 n^2}$. (d) $\frac{n\pi h}{2mL}$.

6. The energy operator is :

   (a) $\frac{\hbar}{i}\frac{\partial}{\partial t}$. (b) $i\hbar\frac{\partial}{\partial t}$.

   (c) $\frac{\hbar}{i}\nabla$. (d) $i\hbar\nabla$.

Turn over

7. The potential function of harmonic oscillator is :

(a) Linear. (b) Parabolic.

(c) Elliptical. (d) Hyperbolic.

8. When a particle of energy $E < V_0$ is incident on a potential barrier of height V_0, then the probability of penetration is :

(a) Zero. (b) 1.

(c) Finite. (d) Infinite.

9. The energy levels of harmonic oscillator according to Schrödinger's equation is :

(a) $n\hbar w$. (b) $\left(n+\frac{1}{2}\right)\hbar w$.

(c) $\frac{\hbar w}{\left(n+\frac{1}{2}\right)}$. (d) $\left(n^2-1\right)\hbar w$.

10. Of the following having the same kinetic energy, which has the longest wavelength :

(a) An electron. (b) Proton.

(c) Neutron. (d) α -particle.

11. For orthogonal wave functions, the value of $\int \psi_m^* \psi_n \, dx$ is :

(a) 1. (b) 0.

(c) ∞. (d) – 1.

12. The waves associated with electrons are called :

(a) Light waves. (b) Sound waves.

(c) Matter waves. (d) Transverse waves.

(12 × ¼ = 3 weightage)

Section B

Answer **all** *questions.*

13. State the principle of superposition of waves.

14. State the postulates of quantum mechanics.

15. Explain uncertainty principle.

16. What is electron spin hypothesis.
17. What do you mean by tunnelling through a barrier ?
18. Explain the significance of wave function.
19. What is correspondence principle ?
20. Distinguish between phase velocity and group velocity.
21. Write Schrödinger's time dependent wave equation.

(9 × 1 = 9 weightage)

Section C

Answer any **five** *questions.*

22. Find the change in wavelength of an X-ray photon when it is scattered through an angle of 90° by a free electron.
23. What voltage must be applied to an electron microscope to produce electrons of wavelength 1A°.
24. Find the normalisation constant of a particle constrained to move in an one dimensional infinite potential well of width L, such that $0 \leq x \leq L$, whose wave function is $\Psi_x = A \sin\left(\frac{n\pi x}{L}\right)$, where n is an integer.
25. Calculate the total energy of the electron in the first Bohr orbit, in electron Volt. (Given electron rest mass $m = 9.11 \times 10^{-31}$ kg, electron charge $e = 1.6 \times 10^{-19}$ C, Planck's constant $h = 6.63 \times 10^{-34}$ Js), permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2 and 1eV = 1.6×10^{-19} J)
26. An electron has a speed of 300 m/s accurate to 0.01 %. With what fundamental accuracy can we locate the position of the electron ?
27. Calculate the value of Bohr radius.
28. Calculate the de Broglie wavelength of neutrons of Kinetic energy 1eV.

(5 × 2 = 10 weightage)

Section D

Answer any **two** *questions.*

29. What is a wave function ? Derive Schrödinger's time Independent equation.
30. Describe Davisson and Gemer experiment for the study of diffraction of electrons and show that the results of this experiment are closely in agreement with de-Broglie wavelength of electrons.

31. (a) Write the time- independent Schrödinger wave equation for the hydrogen atom in spherical polar co-ordinates and separate it into three differential equations for the three parts of the total wave-function.

(b) Solve the azimuthal wave function and show that the magnetic quantum number m_r must be zero or a positive or negative integer.

(2 × 4 = 8 weightage)