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Reg. No.....

FIFTH SEMESTER B.Sc. DEGREE EXAMINATION, NOVEMBER 2014

(U.G.–CCSS)

Core Course—Physics/Applied Physics

PH 5B 10/AP 5B 12—QUANTUM MECHANICS

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*

1. Photoelectric phenomenon was first explained by :

   (a) Bohr. (b) Millikan.

   (c) Einstein. (d) Planck.

2. Neglecting relativistic change of mass, the wavelength associated with an electron of kinetic energy E is proportional to :

   (a) $E^{1/2}$. (b) $E^{-1/2}$.

   (c) E. (d) E^{-1}.

3. The phase velocity (v_p) and group velocity (v_g) of a de-Broglie wave in free space are related as :

   (a) $\frac{v_p}{v_g} = \sqrt{2}$. (b) $v_p v_g = c^2$.

   (c) $\frac{v_p}{v_g} = 0.5$. (d) $v_p v_g = \sqrt{2c^2}$.

4. Of the following moving with the same velocity, the one which has largest wavelength is :

   (a) An electron. (b) A proton.

   (c) A neutron. (d) An α-particle.

5. The existence of matter waves is confirmed by :

   (a) Sten-Gerlach experiment. (b) Frank-Hute experiment.

   (c) Millikan's oil drop experiment. (d) Davidson and Germer experiment.

Turn over

6. The allowed energy valves of a particle in a 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) $\frac{\pi^2\hbar^2}{2mL^2n^2}$.

(d) $\frac{n\,\pi\,\hbar}{2mL}$.

7. The Bohr's quantisation condition is :

(a) $L = \frac{nh}{2\pi}$.

(b) $L = nh$.

(c) $L = -nh$.

(d) $L = \frac{-nh}{2\pi}$.

8. The quantity $|\psi|^2$ represents :

(a) Probability density.

(b) Change density.

(c) Energy density.

(d) Wave intensity.

9. The momentum operator in quantum mechanics is :

(a) $\frac{\hbar}{i}\nabla$.

(b) $-\hbar\nabla$.

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

(d) $\frac{i}{\hbar^2}\nabla$.

10. For normalised wave function the value of $\int_{-\infty}^{+\infty} \psi_m^* \psi_m d_\tau$ is :

(a) 0.

(b) 1.

(c) –1.

(d) ∞.

11. 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) $\left(n^2-1\right)\hbar w$.

12. The expectation value of potential energy in hydrogen atom is :

(a) 13.6 eV. (b) Zero.

(c) –13.6 eV. (d) –27.2 eV.

(12 × ¼ = 3 weightage)

Section B

Answer **all** *questions.*

13. Show that for a non-relativistic free particle, the phase velocity is half the group velocity.

14. What is meant by normalised and orthogonal wave functions ?

15. What are eigenvalves and eigenfunctions ?

16. Explain Zeeman effect.

17. Write Schrödinger's time-independent wave equation.

18. What is Compton effect ?

19. What is zero point energy ?

20. Explain any *one* application of Heisenberg's uncertainty principle.

21. State the postulates of quantum mechanics.

(9 × 1 = 9 weightage)

Section C

Answer any **five** *questions.*

22. The average lifetime of hydrogen in excited state is 2.5×10^{-14} s, calculate the uncertainty in the measurement of energy in this state.

23. Calculate the energy difference between the ground state and the first excited state for an electron in one-dimensional rigid box of length 10^{-10}m (mass of electron = 9.1×10^{-31} kg and $h = 6.63 \times 10^{-34}$ Js).

24. A particle is in motion along a line between $x = 0$ and $x = a$ with zero potential energy, and at points for which $x < 0$ and $x > a$ the potential energy is infinite. The wave function for the particle in the n^{th} state is given by :

$\psi_n = A \sin \frac{n\pi x}{a}$. Find the expressions for the normalized wave functions.

25. Calculate the wave of Bohr magneton. Given $e = 1.6 \times 10^{-19}$ C, $h = 6.62 \times 10^{-34}$ J_s, $m = 9.11 \times 10^{-31}$ kg.

26. What voltage must be applied to an electron microscope to produce electrons of wavelength of 0.5 Å ? Given $e = 1.6 \times 10^{-19}$ C, $m = 9 \times 10^{-31}$ kg, $h = 6.62 \times 10^{-34}$ Js.

27. Calculate the energy and momentum (in eV) of an X-ray photon of wavelength 2 Å.

28. Calculate the work function in electron volt for sodium metal given that photoelectric thr wavelength is 6800 Å.

(5 × 2 = 10 weig

Section D

Answer any **two** *questions.*

29. Obtain Schrödinger wave equation for a particle in one-dimensional rigid box. Solve it to eigenfunctions and show that eigenvalves are discrete.

30. (a) Derive time dependent Schrödinger equation.

    (b) Explain the physical significance of wave function.

31. Describe the Stern-Gerlach experiment for verification of space quantization.

(2 × 4 = 8 weig