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Reg. No. : .....

Name : .....

Fifth Semester B.Sc. Degree Examination, December 2021

First Degree Programme under CBCSS

Physics

Core Course V

PY 1541 : QUANTUM MECHANICS

(2018 & 2019 Admission)

Time : 3 Hours Max. Marks : 80

PART – A

Answer **all** the questions. Each question carries **1** mark.

1. What is photoelectric effect?
2. Give the specific heat of solids.
3. Define the wave nature of particle.
4. The energy of single photon of frequency v is ——————
5. Write ID time independent Schrödinger equation.
6. Write equation of motion in Heisenberg representation.
7. What is zero-point energy of a particle in one dimensional box?

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8. What is infinite square well?

9. Write the probability current density of wave function.

10. What is wave packet?

(10 × 1 = 10 Marks)

PART – B

Answer **any eight** questions. Each carries **2** marks.

11. Explain Compton effect.

12. What is the Plank's quantum hypothesis?

13. What are the postulates of Bohr model of hydrogen atom?

14. State the quantum theory of specific heat of solids.

15. What is wave packet?

16. What is correspondence principle?

17. Explain Hilbert space.

18. Explain expectation value.

19. What happens to the wave function associated with a particle in an infinitely deep potential well?

20. What is zero-point energy of harmonic oscillator? How is it explained?

21. Sketch graphs of ψ and $|\psi|^2$ for the first 4 states of the one-dimensional harmonic oscillator.

22. Write the Schrödinger equation and the form of the wave function in the different regions of a square well with finite depth.

23. Write Hamiltonian operator and angular momentum operator for a particle of mass m moving in a potential $V(x, y, z)$.

24. Explain commuting and anti-commuting operators.

25. Give two important theorems regarding Hermitian operator.

26. Define eigen value and eigen function.

($8 \times 2 = 16$ Marks)

PART – C

Answer **any six** questions. Each carries **4** marks.

27. Explain black body radiation curve.

28. What is the work function of a metal if the threshold wavelength for it is 580 nm? If light of 475 nm wavelength falls on the metal, what is its stopping potential?

29. If a photon has wavelength equal to the Compton wavelength of the particle, show that the photon energy is equal to the rest energy of the particle.

30. State the equation for the energy of the n^{th} state of the electron in the hydrogen atom and express it in electron volt.

31. Show that :

    (a) operators having common set of eigen functions commute;

    (b) commuting operators have common set of eigen functions.

32. The wave function of the particle confined in a box of length a is $\psi(x) = \sqrt{(2/a)}\sin(\pi x/a)$, $0 \le x \le a$, Calculate the probability of finding the particle in the region $0 \le x \le a/2$.

33. For an electron in a one-dimensional infinite potential well of width $1\,\mathring{A}$, calculate :

    (a) the separation between the two lowest energy levels

    (b) the frequency and wavelength of the photon corresponding to a transition between these two levels

    (c) in what region electromagnetic spectrum is this frequency/wavelength.

34. A 1 eV electron got trapped inside the surface of a metal. If the potential barrier is 4 eV and the width of the barrier is $2\mathring{A}$, calculate the probability of its transmission.

35. A harmonic oscillator moves in a potential $V(x)=\frac{1}{2}kx^2+cx$, where C is a constant. Find the energy eigenvalues.

36. Normalize the wave function $\psi(x)=A\exp\left(-ax^2\right)$, A and a are constants over the domain $-\infty\le x\le\infty$.

37. An electron in a 1D infinite potential well, defined by $V(x)=0$ for $-a\le x\le a$ and $V(x)=\alpha$ otherwise, goes from the $n=4$ to $n=2$ level. The frequency of the emitted photon is $3.43x10^{14}$ *Hz*. Find the width of the box.

38. Calculate the probability current density $j(x)$ for the wave function $\psi(x)=u(x)\exp[i\varphi(x)]$

($6\times4=24$ Marks)

PART – D

Answer **any two** questions. Each carries **15** marks.

39. Derive the expression for energy of H atom and obtain frequency of spectral line for Hydrogen like atom.

40. Explain Einstein's theory of photoelectric effect.

41. Define the properties of wave function with condition for physical acceptability, normalization and orthogonality.

42. Explain the Schrödinger equation for a harmonic oscillator.

43. Derive the expression for square well potential with infinite walls.

44. Derive time dependent and independent Schrödinger equations.

($2\times15=30$ Marks)

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