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Reg. No. :

Code No. : 30563 E Sub. Code : SMPH62

**B.Sc. (CBCS) DEGREE EXAMINATION,
APRIL 2020.**

Sixth Semester

Physics – Core

QUANTUM MECHANICS

(For those who joined in July 2017 onwards)

Time : Three hours Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

- For a black body, absorptivity is _____ and emissivity is _____.
 - 1, 0
 - 0, 1
 - 1, 1
 - 0, 0
- Mean thermal energy of an atom is
 - kT
 - 3kT
 - k/T
 - 3T/k

3. In the following equations, which one is true?
- (a) $E^2 = c^4 p^2 + m_o^2 c^2$ (b) $E^2 = c^2 p^4 + m_o^2 c^2$
 (c) $E^2 = c^4 p^2 - m_o^2 c^4$ (d) $E^2 = c^2 p^2 + m_o^2 c^4$
4. The relationship between group velocity and phase velocity is
- (a) $v_g = v_p - \lambda \frac{dv_p}{d\lambda}$ (b) $v_g = v_p + \lambda \frac{dv_p}{d\lambda}$
 (c) $v_p = \lambda v_g - \frac{dv_g}{d\lambda}$ (d) $v_p = v_g - \frac{dv_g}{d\lambda}$
5. The value of \hbar is
- (a) $1.504 \times 10^{-13} \text{ Js}$ (b) $1.054 \times 10^{-31} \text{ Js}$
 (c) $1.045 \times 10^{-13} \text{ Js}$ (d) $1.504 \times 10^{-31} \text{ Js}$
6. The calculated value of radius of the first Bohr Orbit is
- (a) $5.3 \times 10^{11} \text{ m}$ (b) $3.5 \times 10^{11} \text{ m}$
 (c) $0.053 \times 10^{-11} \text{ nm}$ (d) $5.3 \times 10^{11} \text{ nm}$
7. Quantum operator of linear momentum
- (a) $-i\hbar r \times \nabla$ (b) $i\hbar \times \nabla$
 (c) $i\hbar \nabla$ (d) $-i\hbar \nabla$

8. Quantum operator of linear momentum

(a) $-i\hbar \mathbf{r} \times \nabla$ (b) $-i\hbar \frac{\partial}{\partial t}$

(c) $i\hbar \frac{\partial}{\partial t}$ (d) $i\hbar \frac{\partial}{\partial x}$

9. Laplacian operator is

(a) ∇^1 (b) ∇^2

(c) ∇^3 (d) ∇^{-2}

10. Ground state energy value is

(a) $\frac{1}{2}\hbar\omega$ (b) $\frac{3}{2}\hbar\omega$

(c) $\frac{1}{2}h\omega$ (d) $\frac{3}{2}h\omega$

PART B — ($5 \times 5 = 25$ marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 250 words.

11. (a) Derive Wien's displacement law as a consequence of Planck's radiation law.

Or

(b) Prove that in the photo-electric effect from a metal surface, the maximum velocity of photo-electrons is related to the stopping potential by the equation $V_{\max} = 5.927 \times 10^5 \sqrt{V_0}$.

12. (a) Describe the de Broglie's hypothesis for matter waves.

Or

- (b) Calculate the de Broglie wavelength of an electron moving with a velocity of $\frac{3}{5}c$.

13. (a) Predict the lowest possible Kinetic energy of a particle in a box.

Or

- (b) If the speed of an electron is measured as 300 m/s with the accuracy of 0.01%, what will the accuracy of its position be?

14. (a) Brief the postulates of quantum mechanics.

Or

- (b) Derive the one dimensional time independent Schrodinger wave equation.

15. (a) Inspect the motion of a particle in an infinitely deep 1-D potential well using its wave equation and its solution.

Or

- (b) Find the lowest energy of an electron confined to move in 1-D potential box of length 1 \AA .

PART C — ($5 \times 8 = 40$ marks)

Answer ALL questions, choosing either (a) or (b).

Each answer should not exceed 600 words.

16. (a) Explain the black body radiation and distribution of energy in its spectrum.

Or

- (b) Calculate the energy values of an electron in Bohr orbits having principal quantum number n from 1 to 4. Brief the Einstein's quantum theory of specific heat.

17. (a) Explain the Davison & Germer's experiment on the study of diffraction of electrons. Discuss the results.

Or

- (b) Explain a particle in motion by a wave packet.

18. (a) Explain the Gamma ray microscope thought experiment.

Or

- (b) Prove : $\Delta E \cdot \Delta t \geq \hbar$, and also give its physical significance.

19. (a) Write the statement of Ehrenfest's theorem and also prove.

Or

- (b) Give the physical interpretation of the wave function and its limitations. Brief the normalization of wave function.

20. (a) Explain the rectangular potential well.

Or

- (b) Derive and simplify the wave equation for an 1-D Simple Harmonic Oscillator in quantum mechanics. Calculate its total energy E_n .
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