(7 pages) **Reg. No. :**.....

Code No. : 20563 E **Sub. Code : SMPH 62**

B.Sc. (CBCS) DEGREE EXAMINATION, APRIL 2021.

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.

1. In longer wavelength region, Rayleigh-Jean's law describes the energy per unit volume $U_\lambda d\lambda$ is

(a) $\frac{8\pi kT}{\lambda^4}d\lambda$ (b) $\frac{8\pi kT}{\lambda^5}d\lambda$

(c) $\frac{\lambda^4}{8\pi kT}d\lambda$ (d) $\frac{\lambda^5}{8\pi kT}d\lambda$

2. Ground state energy value is

(a) 13.6 MeV (b) 16.3 eV

(c) –13.6 eV (d) –13.6 MeV

3. Propagation constant of a wave is

(a) $\frac{\vec{p}}{h}$ (b) $\frac{\vec{p}}{\hbar}$

(c) $\frac{h}{\vec{p}}$ (d) $\frac{\hbar}{\vec{p}}$

4. Fourier transform of a wave function gives the amplitude as

(a) $\frac{1}{\pi}\int_{-\infty}^{\infty}\psi(x,t)e^{(kx-wt)}dt$

(b) $\frac{1}{\pi}\int_{-\infty}^{\infty}\psi(x,t)e^{(kx+wt)}dx$

(c) $\frac{1}{2\pi}\int_{-\infty}^{\infty}\psi(x,t)e^{i(kx+wt)}dt$

(d) $\frac{1}{2\pi}\int_{-\infty}^{\infty}\psi(x,t)e^{-i(kx-wt)}dx$

5. The uncertainty relation is

(a) $\Delta p \cdot \Delta t \leq \hbar$ (b) $\Delta p \cdot \Delta t \geq \hbar$

(c) $\Delta L \cdot \Delta \phi \geq \hbar$ (d) $\Delta L \cdot \Delta \phi \leq \hbar$

6. The suitable equation for very heavy bodies is

(a) $\frac{\hbar}{m} = 0$ (b) $\frac{m}{\hbar} = 0$

(c) $\frac{\hbar}{m} = \infty$ (d) $\frac{\hbar}{m} = 1$

7. The condition for normalized wave function is

(a) $\frac{1}{\pi}\int_{-\infty}^{\infty} \psi^*(x)\psi(x)dx = 0$

(b) $\int_{-\infty}^{\infty} \psi^*(x)\psi(x)dx = 1$

(c) $\frac{1}{\pi}\int_{-\infty}^{\infty} \psi^*(x)\psi(x)dx = 1$

(d) $\int_{-\infty}^{\infty} \psi^*(x)\psi(x)dx = \infty$

8. The dimension of $|\psi(x, t)|$ is

(a) $[L]^{-½}$ (b) $[L]^{½}$

(c) $[L]^{-2}$ (d) $[L]^{2}$

9. Angular frequency ω is

(a) $\sqrt{\frac{m}{k}}$ (b) $\sqrt{\frac{\lambda}{k}}$

(c) $\sqrt{\frac{k}{m}}$ (d) $\sqrt{\frac{k}{\lambda}}$

10. When does the Potential energy be zero in a potential barrier?

(a) $L < x < 0$ (b) $x = 0$

(c) $x < L$ (d) $L > x > 0$

PART B — (5 × 5 = 25 marks)

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

Each answer should not exceed 250 words.

11. (a) Brief the Planck's quantum hypothesis.

Or

(b) Write a short note on Compton Effect.

12. (a) Obtain the equation, phase constant $k = \frac{2\pi}{\lambda}$ from the concept of wave velocity.

Or

(b) Prove that the deBroglie's wavelength of a particle of mass m, moving with the velocity comparable to the velocity of light, as $\lambda = \frac{h}{\sqrt{2m_o k\left(1 + \frac{k}{2m_o c^2}\right)}}$.

13. (a) Calculate the value of ground state energy of an electron in Bohr orbit.

Or

(b) If the speed of an electron is measured as 300 m/s accurate to 0.01%, with what accuracy can you measure the position of the electron?

14. (a) Derive the one dimensional time independent Schrödinger wave equation.

Or

(b) A particle is moving inside an 1-D infinite potential well between $x = 0$ and $x = a$ with zero potential energy. Its wave function is $\psi_n = A \sin \frac{n\pi x}{a}$. Determine its normalized wave function.

15. (a) Find the condition for mutually orthogonal wave function.

Or

(b) Find the lowest energy of a neutron of mass 1.67×10^{-27} Kg confined to move in 1-D potential box of length 1000 Å.

PART C — (5 × 8 = 40 marks)

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

Each answer should not exceed 600 words.

16. (a) Explore the Einstein's explanation about Photoelectric effect.

Or

(b) Explain Wein's radiation formula and Rayleigh-Jean law with their limitations.

17. (a) Represent the motion of a particle by wave packet. And also prove that $v_g = \frac{d\omega}{dk}$ and $v_p = \frac{\omega_o}{k_o}$.

Or

(b) Analyze the concept of Group velocity with appropriate pictures and mathematical methods. And also prove that $v_g = \frac{d\omega}{dk}$.

18. (a) Prove : $\Delta x \cdot \Delta p_x \geq \hbar$. And also give its physical significance.

Or

(b) Explain the diffraction of electrons at a slit thought experiment.

19. (a) Calculate the expectation values of Potential energy, Kinetic energy and Momentum.

Or

(b) Evaluate the quantum operators for Momentum, Kinetic energy and Total energy.

20. (a) Explain a particle's three dimensional motion in a box and hence prove that $E_{cube} = \frac{\hbar 2\pi^2}{2ma^2}\left(n_x^2 + n_y^2 + n_z^2\right)$.

Or

(b) Describe the tunnel effect and hence determine the reflection coefficient and transmission coefficient.

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