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Reg. No. : .....

Code No. : 5865 **Sub. Code : PPHM 41**

M.Sc. (CBCS) DEGREE EXAMINATION,
APRIL 2020.

Fourth Semester

Physics — Core

QUANTUM MECHANICS — II

(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. $\left[L^2, H\right]$ is equal to ————————

(a) $i\hbar$ (b) 0

(c) $i\hbar\nabla$ (d) $\hbar^2$

2. The spin orbit coupling gives a shift in energy due to electron possessing ————————

(a) L (b) S

(c) Both L and S (d) None

3. In perturbed harmonic oscillator, the first order correction to energy is ————————

(a) $\frac{-e^2E^2}{2mW^2}$ (b) 0

(c) $\frac{e^2E^2}{2mW^2}$ (d) $\frac{E}{2mW^2}$

4. Electric polarizability of hydrogen atom is ————————

(a) $\frac{9}{2}a_0^3$ (b) $\frac{2}{9}a_0^3$

(c) $\frac{9}{2}a_0^2$ (d) None

5. Fermi golden rule is used to describe ———————— rate between states.

(a) transition (b) decay

(c) probability (d) absorption

6. Harmonic perturbation P_{f_i} is large when ————————

(a) $W_{f_i} - W \cong 0$ (b) $W_{f_i} = 0$

(c) $W \cong 0$ (d) $W_{f_i} - W = 1$

7. The cross sectional area of the nucleus is _____

(a) $7.07 \times 10^{-26}\ A^2$ (b) $7.07 \times 10^{-26}\ A^{2/3}$

(c) 7.07×10^{-26} (d) $7.07 \times 10^{-26}\ A^{3/2}$

8. Born approximation for a quantum scattering is valid when the energy is _____.

(a) Very small (b) Sufficiently high

(c) Zero (d) Rapidly vary

9. If a wavefunction transforms into a scalar, which describe a particle of spin is _____

(a) +1/2 (b) –1/2

(c) 0 (d) $\hbar/2$

10. The dirac particle is endowed with spin _____

(a) $\frac{h}{2}\sigma'$ (b) $\frac{\hbar}{2}$

(c) $\frac{\hbar}{2}\sigma'$ (d) +1/2

PART B — (5 × 5 = 25 marks)

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

Each answer should not exceed 250 words.

11. (a) Write a note on spin orbit interaction.

Or

(b) Discuss about ladder operators and Eigen pairs of L^2 and L_2.

12. (a) Explain the hyperfine splitting of the ground state of hydrogen.

Or

(b) Give the calculation of $E_n^{(2)}$ by Dalgaino and Lewis method.

13. (a) Discuss the transition probability in adiabatic perturbation.

Or

(b) Explain constant perturbation.

14. (a) Write a note on scattering from a square well system using partial wave analysis.

Or

(b) Determine the phase shift for the scattered wave.

15. (a) Find out the energy of an electron in a magnetic field.

Or

(b) Derive Dirac Hamiltonian and Dirac matrices for a free particle.

PART C — (5 × 8 = 40 marks)

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

Each answer should not exceed 600 words.

16. (a) Explain orbital angular momentum with quantum mechanical operators.

Or

(b) Critically analyse the matrix representation of angular momentum operators. Show that $L^2 |l, m\rangle = l(l+1)\hbar^2 |l, m\rangle$

$L_z |l, m\rangle = m\hbar |l, m\rangle$

17. (a) Using time independent perturbation theory explain perturbed linear harmonic oscillator.

Or

(b) Explain the perturbation theory for degenerate levels.

18. (a) Calculate the Einstein co-efficients in an oscillating electric field $E(t) = e E_0 \cos wt$.

Or

(b) The motion of a particle of mass m in a linear harmonic oscillator is subjected to an applied electric field during the time t = 0 to T. Assume that the initial state of the system is ϕ_i and the perturbation to the Hamiltonian is $H^{(1)} = -eEx$. Find the probability for the transition to the state ϕ_f in time T.

19. (a) Find the scattering amplitude for a quantum mechanical system using Green's function approach.

Or

(b) Determine the total scattering cross section in centre of mass frame using laboratory coordinates system.

20. (a) Derive the spin-orbit energy of a system using Dirac's equation.

Or

(b) Construct the Klein-Gordan equation and find out the current density.

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