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M.Sc. (CBCS) DEGREE EXAMINATION,
APRIL 2018.

Fourth Semester

Physics

QUANTUM MECHANICS — II

(For those who joined in July 2016 and afterwards)

Time : Three hours

Maximum : 75 marks

PART A — (10 × 1 = 10 marks)

Answer ALL questions.

Choose the correct answer :

1. The energy gap between the triplet and singlet states of hyperfine splitting of the ground state of hydrogen is _____

- (a) 3.1268×10^{-7} eV
- (b) 5.884×10^{-6} eV
- (c) 13.6 eV
- (d) -13.6 eV

2. The second order correction of energy of a perturbed linear harmonic oscillator can be expressed as _____

- (a) $-\frac{e^2 E^2}{2mw^2}$
- (b) $\frac{e^2 E^2}{2mw^2}$
- (c) $(n + 1/2)\hbar w - \frac{\lambda^2 e^2 E^2}{2mw^2}$
- (d) $(n + 1/2)\hbar w + \frac{\lambda^2 e^2 E^2}{2mw^2}$

3. According to first order transition probability, the selection rule for transition for i^{th} state to f^{th} state be forbidden is _____

- (a) $H_{if} \neq 0$
- (b) $H_{if} = 0$
- (c) $H_{fi} = 0$
- (d) $H_{fi} \neq 0$

4. Fermi golden rule is often used to describe the _____

- (a) transition rate between energy states
- (b) ground state energy
- (c) excited state energy
- (d) transition between spin states



5. The exact expression for ground state energy of hydrogen atom is _____

- (a) $-\frac{me^4}{(2\hbar)^2}$ (b) $-\frac{me^2}{(2\hbar)^2}$
 (c) $-\frac{me^2}{2\hbar^2}$ (d) $-\frac{me^4}{2\hbar^2}$

6. The SI unit of the proportionality constant ($d\sigma/d\Omega$) is _____

- (a) area/radian (b) area/steradian
 (c) volume/radian (d) volume/steradian

7. Which of the following particle obey Fermi-Dirac statistics _____

- (a) C^{12} (b) Photon
 (c) He^3 (d) π meson

8. States with parallel and antiparallel spins are called _____ and _____ state respectively

- (a) singlet, triplet
 (b) symmetric, asymmetric
 (c) like, unlike
 (d) ortho, para

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9. The covariant form of Dirac equation is _____

- (a) $\sum_{k=1}^4 \gamma_k \frac{\partial \psi}{\partial x_k} + \frac{mc}{\hbar} \psi = 0$
 (b) $\sum_{k=1}^4 \gamma_k \frac{\partial^2 \psi}{\partial x_k^2} + \frac{mc}{\hbar^2} \psi = 0$
 (c) $\sum_{k=1}^4 \gamma_k \frac{\partial \psi}{\partial x_k} + \frac{mc}{\hbar^2} \psi = 0$
 (d) $\sum_{k=1}^4 \gamma_k \frac{\partial^2 \psi}{\partial x_k^2} + \frac{mc}{\hbar} \psi = 0$

10. According to Dirac, the Hamiltonian for a free particle is $E =$

- (a) $c.p + \beta mc^2$ (b) $\alpha.p + mc^2$
 (c) $\alpha.p + \beta mc^2$ (d) $c\alpha.p + \beta mc^2$

PART B — (5 × 5 = 25 marks)

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

Each answer should not exceed 250 words.

11. (a) Explain the application of nondegenerate level using hyperfine splitting of the ground state of hydrogen.

Or

(b) Derive the first order correction of nondegenerate case.

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[P.T.O.]



12. (a) Derive an expression for transition probability by adiabatic perturbation.

Or

- (b) Determine the energy levels of an one dimensional potential well using WKB method.
13. (a) Determine the ground state energy of harmonic oscillator using variational method.

Or

- (b) Write a short notes on classical scattering cross section.
14. (a) Derive the spin matrices for $S = 1/2$.

Or

- (b) Write short note on symmetric and antisymmetric wave function.
15. (a) Construct the Klein-Gordon equation for relativistic free particle. Also list out the inadequacies of KG equation.

Or

- (b) Derive the Dirac equation for an electron in an electromagnetic field.

PART C — ($5 \times 8 = 40$ marks)

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

Each answer should not exceed 600 words.

16. (a) Discuss briefly the first order stark effect in hydrogen.

Or

- (b) Derive the second order correction of non degenerate case using Dalgarn and Lewis method.
17. (a) Discuss briefly the semi classical theory of radiation and calculate the Einstein coefficients.

Or

- (b) Explain in detail the theory of α -decay and cold emission of electrons from metal using WKB method.
18. (a) Derive the ground state energy of hydrogen molecule using linear combination method.

Or

- (b) Write a short notes on Born approximation and derive the validity condition for a square well potential.



19. (a) Discuss in brief the permutation symmetry.

Or

(b) Derive the expression for differential scattering cross section of collisions between identical particles.

20. (a) Derive the Dirac matrices and Dirac equation in covariant form for a free particle.

Or

(b) Discuss in detail the Klein paradox.

