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M. Sc. (THIRD SEMESTER)
EXAMINATION, Dec. - Jan., 2021-22
(PHYSICS)
PAPER FIRST
(QUANTUM MECHANICS - II)

Time : Three Hours] ***[Maximum Marks:80***

Note : Attempt all sections as directed.

Section - A

(1 Mark each)

(Objective/Multiple Choice Questions)

(1×20=20 marks)

Note: Attempt all questions.

Choose the correct answer:

1. Classical turning points correspond to the following situation in WKB approximation.
   (A) E = 0
   (B) V = 0
   (C) E - V = 0
   (D) None of the above

P.T.O.

2. WKB approximation is known as
   (A) Quantum approximation
   (B) Classical approximation
   (C) Semiclassical approximation
   (D) All of the above
3. The variation method is best suited to calculate energies in the:
   (A) I[st] excited state
   (B) II[nd] excited state
   (C) Both (A) and (B)
   (D) Ground state
4. In calculation of lowest upper limit for the ground state energy of He atom using variation method gives accurate results at $Z = \frac{27}{16}$ not $Z = 2$ due to :
   (A) Improper trail function
   (B) Quantum confinement
   (C) Error in Variatioin Method
   (D) Screening effect
5. Green's function for any linear differential operator Ω follows the equation :
   (A) $\Omega\,(x, \nabla)\,G\,(x\,x') = \delta\,(x - x')$
   (B) $\Omega\,(x, \nabla)\,G\,(x\,x') = G\,(x\,x')$
   (C) $\Omega\,(x, \nabla)\,G\,(x\,x') = G'\,(x\,x')$
   (D) None of the above

6. Which of the following statement is correct, if we add any Green's function '*G*' to any solution '*S*' of a homogeneous equation Ω S = 0

(A) $\Omega\ G = \delta\ (x - x')$

(B) $\Omega\ S = \delta\ (x - x')$

(C) $\Omega = (G - S) = \delta\ (x - x')$

(D) $\Omega (G + S) = \delta\ (x - x')$

7. The asymptotic scattered wave function can be written as:

(A) $\text{Usc} = e^{ikr}$

(B) $\text{Usc} = (\text{f}(\theta,\phi)e^{ikr})/r$

(C) $\text{Usc} = f(\theta,\phi)$

(D) None of these

8. Quantum mechanically, the phenomena of scattering is described as a distortion in the stationary wave pattern caused by:

(A) Reflection

(B) Collision

(C) Presence of a scattering center

(D) Only (B) and (C)

9. Fermi's Golden Rule calculates.

(A) Transition probability

(B) Transition probability per unit time

(C) probability density

(D) All of the above

10. Which of the following method is to be used for a perturbation varying slowly with time:

(A) WKB Method

(B) Variation Method

(C) Sudden Approximation

(D) Adiabatic approximation

11. The scattering amplitude for identical particle is given as:

(A) $f(\theta,\phi)$

(B) $|f(\theta,\phi)|^2$

(C) $f(\theta,\phi) \pm f(\pi-\theta,\phi+\pi)$

(D) $f(\theta,\phi) \pm f(\pi)$

12. The validity condition for sudden approximation can be written as:

(A) $\omega f_i \tau >> 1$

(B) $\omega f_i \tau << 1$

(C) $\omega f_i \tau = 1$

(D) None of the above

13. Under the action of electrotomagnetic field the momentum of a particle is modified as follows:

(A) $P \Rightarrow P - e/c$

(B) $P \Rightarrow P - eA/c$

(c) $P \Rightarrow P + eA/c$

(D) No change

14. Klein-Gordon equation is valid only for:

(A) spin $1/2$ particle

(B) spin 1 particle

(C) spin 0 particle

(D) any particle

15. The form of Diva Hamiltonian is:

(A) $H = \frac{p^2}{2m} + v$ (B) $H = p^2c^2 + m^2c^4$

(C) $H = c\alpha.p + \beta mc^2$ (D) $H = c\alpha.p + \beta mc^{2-}$

16. For dirac's α and β matrices, the following statements are true:

(A) $\alpha_i^2 = 1$ (B) $\alpha_x\alpha_y + \alpha_y\alpha_x = 0$

(C) $\alpha_x\beta + \beta\alpha_x = 0$ (D) All the above

17. Divac's equation describes particle with spin:

(A) 1/2

(B) 1

(C) zero

(D) 2

18. The difference between negative and positive energy states of Divac particles is :-

(A) mc^2

(B) $2mc^2$

(C) m/c^2

(D) no separation.

19. In Dirac hamiltonian the following term conples the orbital motion of electron to its spin :

(A) β mc^2

(B) cα p

(C) Both (A) and (B)

(D) None of the above

20. As per Dirac, all the negative energy states are occupied by:

(A) Positron

(B) Holes

(C) Electrons

(D) Not accupied

Section - B

(2 Marks each)

(Very short answer type questions)

Note- Attempt all questions.

1. Write trial function for hydrogen atoms which can be used in variation method.
2. Write the value of minimum energy obtained for the atom using variation method.
3. Discuss scattering cross section.
4. Construct symmetric and antisymmetric wave function.
5. Write an expression for charge density as per Klein-Gorden equation.
6. Write an expression for probability current density for Dirace equation.
7. Write the anticommutation properties of Dirac's α and β matrices.
8. Define spin of Dirac particles in terms of Dirac's α matrices.

Section - C

(3 Marks each)

(Short answer type questions)

(8×3 = 24 marks)

Note- Attempt all questions.

1. Write the process of obtaining best estimate of the energy of the first excited state using variation method.
2. Discuss vander waal's interaction.
3. Obtain scattering amplitude in terms of phase shifts of partial waves.
4. Explain how is the scattering of identical particles described in quantum mechanics.

5. Show the Lorentz covariance of Dirac equation.
6. Show that the probability density 'P' and probability current density 'S' satisfy continuity equation in Dirac formulation.
7. Obtain energy spectrum of a Dirac particle by solving Dirace equations for plane waves.
8. Obtain an expression for spin of a Dirac particle.

Section - D

(5 Marks each)

(Long answer type questions)

(4×5=20 marks)

Note : Attempt all questions.

1. Calculate energy levels of a potential well problem using WKB approximation method.

   Or

   Derive the connection formulae for WKB solutions near turning points.

2. Obtain an expression for scattering cross section for scattering by a square well.

   Or

   Obtain differential cross section for scattering by coulomb potential.

3. Obtain transition probability for Harmonic perturbations.

   Or

   Obtain expressions for Dirac's α and β matrices.

4. Find the energy eigen values of a relativistic Dirac particle moving under central field.

   Or

   Calculate the spin-orbit interaction energy of a Dirac particle.