QP CODE: 23002670

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Reg No : .....

Name : .....

M Sc DEGREE (CSS) EXAMINATION, MARCH 2023

Third Semester

Faculty of Science

CORE - PH010301 - QUANTUM MECHANICS-II

M Sc PHYSICS, M Sc SPACE SCIENCE

2019 ADMISSION ONWARDS

63ACD42C

Time: 3 Hours Weightage: 30

Part A (Short Answer Questions)

*Answer any **eight** questions.*

*Weight **1** each.*

1. Distinguish between degenerate and non degenerate perturbation theory.
2. Explain the approximation used in WKB method
3. Briefly discuss how WKB method can be used to analyze alpha decay problem.
4. Write down the Hamiltonian of classical radiation field and explain the terms therein.
5. What is the density of states of electrons if a photoelectric material is treated as a cube?
6. Explain exchange degeneracy for a system of identical particles.
7. State true or false : Partial wave expansion is most useful when incoming beam has low momentum. Justify your answer with reason.
8. State *true* or *false* with proper justification : Greens function for scattering problem is an outgoing spherical wave.
9. Is Klein-Gordon equation Lorentz invariant? Give reason.
10. Is the momentum of a free Dirac particle conserved? Answer with reason.

(8×1=8 weightage)

Part B (Short Essay/Problems)

*Answer any **six** questions.*

*Weight **2** each.*

11. What is the need of perturbation theory?

12. Using $\psi(x) = A\, e^{-b|x|}$ as the trial wave function, estimate the ground state energy of a harmonic oscillator.

13. A particle in one dimension moves in a potential $V(x) = V_0 \left(1 - e^{-\frac{(x-x_0)^2}{2\sigma^2}}\right)$ where V_0, x_0 and σ are positive real constants. If the energy E of the particle is $E < V_0$, find the turning points and write down the wavefunctions representing the state of the particle in the regions away from the turning points.

14. Show that the transition probability is the same in interaction picture and Schrodinger picture for a system evolving from an initial state to a final state.

15. Show that the probability of states exhibits an oscillatory time dependence when the of two level system is perturbed by a sinusoidal oscillating potential.
Given: $H_0 = E_1\ |1\rangle\langle 1| + E_2\ |2\rangle\langle 2|$ and $V(t) = \gamma e^{i\omega t}\ |1\rangle\langle 2| + \gamma e^{-i\omega t}\ |2\rangle\langle 1|$.

16. Define scattering cross section and show that it is equal to the square of the scattering amplitude.

17. Define scattering amplitude, phase shift in a collision process and establish suitable relation amongst them.

18. For a free Dirac particle, let ψ_+ and ψ_- be eigenstates of energy with eigenvalues E and $-E$ respectively. Find $\psi_+^\dagger\, \alpha^k \psi_-$. (α^k is any Dirac matrix with $k = 1, 2, 3$.)

(6×2=12 weightage)

Part C (Essay Type Questions)

*Answer any **two** questions.*

*Weight **5** each.*

19. Discuss the estimation of ground state energy of Helium atom using variational technique.

20. Explain Dyson series. Obtain expressions for the time development of initial and final state probability amplitudes $c_i(t)$ and $c_n(t)$ upto first order, for the perturbation $V(t) = e^{\eta t} V$ where η is small and positive.

21. Describe the scattering of a charged particle by the Coulomb field of nuclei using the first Born approximation.

22. Write down Dirac equation and explain the terms therein. Show that the Dirac wavefunction provides a probability density $\rho(\mathbf{r}, t) \geq 0$ by obtaining the current conservation equation.

(2×5=10 weightage)