QP CODE: 25047323

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Reg No : .....

Name : .....

M.Sc DEGREE (CSS) EXAMINATION, NOVEMBER 2025

Third Semester

Core Course - PH010301 - QUANTUM MECHANICS-II

M.Sc PHYSICS, M.SC SPACE SCIENCE

2019 ADMISSION ONWARDS

F171490E

Time: 3 Hours Weightage: 30

Part A (Short Answer Questions)

*Answer any **eight** questions.*

*Weight **1** each.*

1. What is a Gaussian trial wave function in variational method? Why is it suitable as a trial wavefunction for harmonic oscillator problem?
2. Write the Hamiltonian of the Hydrogen molecule ion and explain the terms therein.
3. How can we find tunneling amplitude using WKB method?
4. A system undergoing a time dependent perturbation $V(t)$ has a Hamiltonian $H_0 + V(t)$. Write down the expression for $\frac{d}{dt}U_I(t,t_0)$ the derivative of the time evolution operator in the interaction picture.
5. Absorption cross section of an atom interacting with electromagnetic radiation is $10^{-27}\mathrm{m}^2$. If this atom is found to absorb energy at a rate of $1.8 \times 10^{-6} J\ s^{-1}$, find the flux of the electromagnetic radiation.
6. State true or false : Partial wave expansion is most useful when incoming beam has low momentum. Justify your answer with reason.
7. Define differential scattering cross section and total scattering cross section.
8. Write down the expression for the scattering amplitude in Born approximation and express the scattering cross section in the approximation.
9. Find the determinants of the Dirac matrices $(\boldsymbol{\alpha}, \beta)$.
10. Find the velocity operator for a free Dirac particle.

(8×1=8 weightage)

Part B (Short Essay/Problems)

*Answer any **six** questions.*

*Weight **2** each.*

11. Explain the first order correction to an energy level and corresponding eigenstate due to a perturbation.

12. Write the Hamiltonian of hydrogen atom when it is perturbed by electric field. Why do we need degenerate perturbation theory to study this?

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. A system is in its energy eigenstate $|m\rangle$ at time $t = 0$. If the system is perturbed by a constant potential during time $0 \leq t \leq t_1$, obtain the probability to find it in another energy eigenstate $|n\rangle$ at time t_1.

16. Show that the wave function of a system of identical particles is either totally symmetric or totally antisymmetric.

17. Prove that σ is the imaginary part of the forward scattering amplitude.

18. Show that a wavefunction obeying Klein-Gordon equation cannot always provide a positive probability density.

(6×2=12 weightage)

Part C (Essay Type Questions)

*Answer any **two** questions.*

*Weight **5** each.*

19. What is WKB approximation method. Derive the WKB wavefunction for the non classical region.

20. Derive an expression for absorption cross section in the case of photoelectric effect using time dependent perturbation problem.

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

22.
    1. Explain how Dirac theory accounts for negative energy states?
    2. For a Dirac particle moving in X direction with momentum p, write down postive and negative energy wavefunctions that are eigenstates of S_z and show that they are orthogonal to each other.

(2×5=10 weightage)