

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
DEPARTMENT OF PHYSICS

M.Sc. I PHY- 4203 Quantum Mechanics-II

(QUESTION BANK)

- 1) What is scattering cross-section? Explain differential cross-section, total cross-section.
2) In case of scattering by rigid sphere of radius 'a' show that scattering cross section for S-wave is $4\pi a^2$.

3) Obtain Slater determinant for N-particle system.

4) Show that the total energies in Laboratory & Centre of mass system is related by

$$E_{\text{lab}} = \frac{m_1 + m_2}{m_2} E_{\text{cm}}$$

5) Using spin function obtain symmetric & Antisymmetric wave function for system of two electrons.

6) Discuss centre of mass & laboratory frame of reference with reference to scattering cross-section.

7) Using Partial wave analysis show that total scattering cross-section is given by

$$\sigma_{\text{total}} = \frac{4\pi}{k^2} \sum_{l=0}^{\infty} (2l + 1) \sin^2 \delta_l$$

8) Calculate the differential cross section in the Born approximation for the potential Yukawa potential.

9) Describe Schrodinger picture and Heisenberg picture.

10) Explain collision of identical particles?

11) Explain Optical theorem.

12) State & explain Pauli's exclusion principle for system of two fermions.

13) Using Born Approximation calculate differential scattering cross-section for potential

$$V = -V_0 \exp(-r/a) \quad \text{where, } r \rightarrow 0 \text{ to } \infty$$

14) Explain Optical theorem.

15) Explain the bound states for potential well with NO rigid walls.

16) Consider the scattering of a particle of mass m from a sphere potential

$$V(r) = V_0 \text{ for } r < a \text{ and } V(r) = 0 \text{ for } r > a$$

Calculate the total cross section in the low energy limit.

17) Calculate the differential cross section in the Born approximation for Yukawa potential.

18) Obtain Slater determinant for N- identical particles.

19) Using variational method obtain ground state energy of the Hydrogen atom for which trial wave function is $\psi = A \exp(-\alpha r)$. 20)

What is WKB approximation? State its validity.

21) Explain the collision of identical particle. 22)

Explain the bound states for potential well with ONE & TWO rigid walls.

23) Discuss concept of symmetry in Quantum Mechanics.

24) Using Time-

dependent perturbation theory, obtain first order transition amplitude.

25) Show that

there is no first order Stark effect in the ground state of an atom.

26)

Construct Symmetric & Antisymmetric wave function for two electron atom.

27) Explain basic principle of Variational method.

28) Use the variational method to estimate the energy of the ground state of one dimensional harmonic oscillator using trial wave function $\psi = A \exp(-\alpha x^2)$, where A & α are constant.

29) Apply time independent perturbation to degenerate system.

- 30) What is quantum mechanics? Explain with example.
- 31) What are the application of quantum mechanics?
- 32) What is relation between angles in C-system and L-system?
- 33) What is scattering amplitude? How it is related with scattering cross-section?
- 34) Using born approximation obtain an expression for differential scattering cross section for Screened Coulomb field and scattering by square well potential.
- 35) Using born approximation obtain an expression for differential scattering cross section for Yukawa Potential
- 36) Explain partial wave analysis.
- 37) construct symmetric and antisymmetric wavefunctions for two particles.
- 38) Explain Klein-Gordon equation in presence of electromagnetic field.
- 39) Derive an expression for application of Klein-Gordon equation to hydrogen atom.
- 40) Explain Dirac's relativistic equation for a free electron.
- 41) What are the properties of alpha and beta matrices?
- 42) What is mean by Gamma matrices?
- 43) What are the properties of Gamma matrices?
- 44) Explain negative energy states.
- 45) Derive Dirac's equation in electromagnetic field.
- 46) Explain Dirac's equation covariant form.
- 47) what is exchange symmetry of wavefunctions?
- 48) Explain Schrodinger's picture.
- 49) Explain Heisenberg Picture in Q.M.
- 50) What is mean by Interaction picture?
- 51) Prove that the average value of time derivative of a physical quantity, which does not explicitly depends on time, is equal to zero in a stationary states. (page 575 KG)
- 52) For a linear Harmonic oscillator find the expression for position and momentum in Heisenberg picture.
- 53) Find out the condition when a Hermitian matrix will also be unitary.
- 54) Explain the matrix representation of generators for $j=1/2$ and $j=1$.

- 55) Using variational method obtain ground state energy of the Hydrogen atom for which trial wave function is $\psi = A \exp(-\alpha r)$.
- 56) Using Time-dependent perturbation theory, obtain I^{st} & I^{nd} order transition amplitude.

- 57) Show that there is no first order Stark effect in the ground state of Hydrogen atom.

- 58) Explain basic principle of Variational method.

- 59) Use the variational method to estimate the energy of the ground state of one dimensional harmonic oscillator using trial wave function $\psi = A \exp(-\alpha x^2)$, where A & α are constant.
- 60) Explain Harmonic perturbation & Einstein coefficient for spontaneous emission.
- 61) Explain degeneracy associated with symmetries.

- 62) What is rotation group?

- 63) Explain Wigner-Eckart theorem.

- 64) Explain space translation.

- 65) Explain time translation.

- 66) Explain time dependent perturbation theory.
- 67) What is meant by perturbation.
- 68) What is scattering? Explain types of scattering.
- 69) Explain Fermi's Golden rule.
- 70) What is Harmonic perturbation?
- 71) What is approximation? What are the types of approximations in Q.M?
- 72) What do you mean by collision. Explain with one example.
- 73) Define stimulated emission.
- 74) What is spontaneous emission?
- 75) What is Bohr's quantisation rule?
- 76) What do you mean by degeneracy?
- 77) What is non-degenerate state?
- 78) What is scattering cross-section? Explain differential cross-section, total cross-section.
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