Dr. AK

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Manipal University, Manipal
Second Semester M.Sc.(Physics)
End Semester Examination, May 2016
Subject: Quantum Mechanics II (PHY-606)
(Credit System)

Main examination

Time: 3 hours Marks: 50

Answer any five full questions.

1. (i) Calculate normalized eigenvector of the Pauli matrix σ_x. [3]
(ii) Show that L^2 and L_y can be measured simultaneously. [2]
(iii) Calculate all the Clebsch-Gordan coefficients for a system having $j_1 = \frac{1}{2}$ and $j_2 = \frac{1}{2}$. [5]
2. (i) Using variational principle show that $< \psi_{trial}|H|\psi_{trial} > \geq E_g$. [3]
(ii) If the first $(n-1)$ exact eigenfunctions of a particular system are known, write a formal expression for a variational trial function for the nth excited state. [2]
(ii) Obtain the energy values of harmonic oscillator by the WKB method. [5]
3. (i) For a two fold degenerate system calculate the first order correction to energy using time independent perturbation theory. [5]
(ii) A particle of mass m and charge e oscillates along the x-axis in a one-dimensional harmonic potential with an angular frequency ω. If an electric field E is applied along the x-axis, write the expression for perturbative Hamiltonian of the system. [2]
(iii) Explain the Stark effect. [3]
4. (i) Argue that according to quantum mechanics there is no spontaneous emission process. [3]
(ii) Give physical interpretation of the linear coefficients of time dependent wavefunctions. [2]

(iii) A particle of mass m having charge e, confined to a three-dimensional cubical box of side $2a$, is acted on by an electric field

$$E = E_0 exp(-\alpha t). \qquad t > 0$$

where α is a constant, in the x-direction. Calculate the probability that the charged particle in the ground state at $t = 0$ is excited to the first excited state by the time $t = \infty$. [5]

5. (i) For a quantum scattering process show that $\sigma(\theta) = |f(\theta)|^2$. [3]
(ii) Write the integral equation form of the Schroedinger equation and explain the meaning of symbols used. [2]
(iii) Use Born approximation to calculate the differential scattering cross section for a particle of mass m moving in the potential $V(r) = Aexp(-r^2/a^2)$, A and a are constants. [5]

6. (i) Explain how the KG equation leads to positive and negative probability density values? [5]
(ii) Obtain the plane wave solutions of the Dirac equation. [5]

Useful formulae:

$$\nabla^2 t = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial t}{\partial r}\right) + \frac{1}{r^2 sin\theta}\frac{\partial}{\partial\theta}\left(sin\theta\frac{\partial t}{\partial\theta}\right) + \frac{1}{r^2 sin^2\theta}\frac{\partial^2 t}{\partial\phi^2}$$

$$\int_0^\infty exp(-a^2x^2)cos(bx)\,dx = \frac{\sqrt{\pi}}{2a}exp\left(-\frac{b^2}{4a^2}\right)$$