Boğaziçi University
Department of Physics

Phys 311/407 Summer 2014

Problem Set #9

Reading: Rohlf 8.4 – 8.9

Problem 1:

Consider an electron in an infinite well of width 0.05 nm. a) What is the ground state energy? b) What is the first excited state energy?

Problem 2:

Obtain an expression for the wavelength of a photon emitted when an electron in an infinite well of width L makes a transition from a state of quantum number n to the ground state.

Problem 3:

Consider an infinite potential well defined between $x = 0$ and $x = L$. The solution of the Schrödinger Equation yields; $\psi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$ as the wave functions for the n^{th} state, and $E_n = \frac{\hbar^2 n^2 \pi^2}{2mL^2}$ as the energy of the n^{th} state. Assume that a particle is in such a state that its wave function is given by

$$\psi(x,t) = \frac{1}{\sqrt{2}} \left(\psi_2(x) e^{-iE_2 t/\hbar} + \psi_3(x) e^{-iE_3 t/\hbar} \right)$$

a) Show that this is a solution for the time dependent Schrödinger Equation, [Hint: Note that the Schrödinger Equation is a perfectly linear equation. If you show that each term of the wavefunction satisfies the equation independently, then the sum of the terms should also satisfy it.]

b) Show that it is normalized $[1 \stackrel{?}{=} \int \mathrm{d}x \, |\psi(x,t)|^2]$. What does it say about the whereabouts of the particle at any given time?

c) Find the probability of finding the particle between $x = 0$ and $x = L/2$ as a function of time. What is the period of oscillation of the probability? Describe how the particle behaves in the box in words.

Problem 4:

Consider a particle in a three dimensional box of size $\frac{L}{1} \times \frac{L}{\sqrt{3}} \times \frac{L}{2}$. Find the allowed states that have the five lowest energies. Show the quantum numbers (Ex: E_{111}, E_{112}, *etc.*) and the energies for each of those states. Indicate the degeneracies, if any. What is the quantum number and the energy of the next degenerate state?