Assignment 7

Due Wednesday, October 27, 2010

Announcements: Quiz 3 will be given on Monday, October 25. It will cover material through that discussed in lecture on Friday, October 22 (see assignment below).

Topics: Our exploration of the nature of light has led to the conclusion that it exhibits both wave-like and particle-like properties. But these observations and Einstein's theory of relativity lead us to ask the question, "If light can behave like particles, can particles behave like waves?" One might devise a diffraction experiment to test this hypothesis, and such experiments have demonstrated the wave nature of electrons and other small objects. This implies that there is no great distinction between light and matter; they exhibit equally strange behavior. How are we to interpret the wave nature of the electron? One possible explanation is that the electron wave is related to the probability of finding it at some location, but we can never pinpoint its location exactly. To explain these observations, we need to develop a new quantum mechanical model for small objects such as photons, electrons, and atoms. Among other things, the model we develop must explain observed phenomena such as the emission spectrum of the hydrogen atom, which exhibits lines of discrete wavelength.

Reading & Problems: Zumdahl, 6^{th} edition

Date	Lecture	Reading	Problems
Wednesday 10/20	Failures of Classical Mechanics	Section 12.2 thru p. 528 (Stop at "Thus light…")	Chapter 12: Discussion Question #1, #22, 24, 27, 112
Friday 10/22	The H-atom spectrum and Bohr model	Sections 12.3 – 12.4	Chapter 12: #36, 38, 42 (b & d only), 129
Monday 10/25	Matter Waves	Section 12.2 p. 528-530	Chapter 12: #28, 30, 32, 130
Wednesday 10/27	Uncertainty Principle, Schroedinger eqn	Section 12.5, 12.7	

Notes:

- For #27, also draw a graph of the kinetic energy of the ejected electron as a function of the frequency of light used. Indicate how the work function of the metal relates to the graph. What is the value of the slope of the line and its significance?
- In #112, the *specific heat capacity* is the amount of energy (in J) required to increase the temperature of 1 g of water by 1 °C. Note that the energy delivered by the microwave is given in J/s. Based on these definitions, the amount of water in the cup, and the required temperature change, you should be able to calculate the amount of time required to boil the water.

Challenge Problem:

A He^+ ion in the ground state absorbs a photon of wavelength 24.3 nm.

a. What is the quantum number, n, of the excited (final) state?
b. The excited helium ion then emits a photon to transition to the n=2 state. What is the wavelength of the emitted light? Would the emission be visible? If not, in what region of the electromagnetic spectrum does it appear?
c. Draw an energy level diagram for the He^+ ion. You do not have to calculate the exact energy of each level, but pay attention to the relative spacing of the energy levels and be sure to label each level. Show the two transitions from parts a and b on the diagram.
d. What characteristics of the H atom spectrum could not be explained using classical mechanics? (Explain, in as much detail as possible, why the H-atom spectrum was one of the experimental results that led to the development of quantum mechanics.)