Physics 202H - Introductory Quantum Physics I Homework #06

Fall 2004 Due 5:01 PM, Monday 2004/11/01

[65 points total]

"Journal" questions. Briefly share your thoughts on the following questions:
– About how much time per week are you spending on the various aspects of this course, outside of scheduled class times? (ie: lab, assignments, non-assignment pre-reading, general studying, etc.?) About how much time do you think that you SHOULD be spending on the various aspects of this course? Do you have any suggestions on how the course could be arranged to reduce the course workload without significantly reducing the amount and depth of material covered?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. (From Eisberg & Resnick, Q 4-9, pg 120) For the Bohr hydrogen atom orbits, the potential energy is negative and greater in magnitude than the kinetic energy. What does this imply? Limit your discussion to about 50 words or so. [10]

2. (From problem 2-27, "Simple Nature", Crowell, pg 107) Assume that the kinetic energy of an electron the $n = 1$ state of a hydrogen atom is on the same order of magnitude as the absolute value of its total energy, and estimate a typical speed at which it would be moving. (It cannot really have a single, definite speed, because its kinetic and interaction energy trade off at different distances from the proton, but this is just a rough estimate of a typical speed.) Based on this speed, were we justified in assuming that the electron could be described nonrelativistically? [10]

3. (From problem 2-33, "Simple Nature", Crowell, pg 108) A muon is a subatomic particle that acts exactly like an electron except that its mass is 207 times greater. Muons can be created by cosmic rays, and it can happen that one of an atom's electrons is displaced by a muon, forming a muonic atom. If this happens to a hydrogen atom, the resulting system consists simply of a proton plus a muon.
   (a) Based on the results of Crowell Section 2.4.4, how would the size of a muonic hydrogen atom in its ground state compare with the size of the normal atom? [10]
   (b) If you were searching for muonic atoms in the sun or in the earth's atmosphere by spectroscopy, in what part of the electromagnetic spectrum would you expect to find the absorption lines? Why? (Hint: See Eisberg & Resnick, P 4-30, pg 122.) [5]

4. (From Eisberg & Resnick, P 4-33, pg 122) Using Bohr's model, calculate the energy required to remove the electron from singly ionized helium. [5]

5. (From Eisberg & Resnick, P 4-35, pg 122) A 3.00 eV electron is captured by a bare nucleus of helium. If a 2400 Å photon is emitted, into what level was the electron captured? [5]

6. How is the de Broglie wavelength related to Bohr's quantization of angular momentum? In this case what is the periodic function that the Wilson-Sommerfeld rule is applied to? Limit your discussion to about 50 words or so. [10]

7. (From Eisberg & Resnick, P 4-43, pg 123) Assume the angular momentum of the earth of mass $m_\oplus = 6.0 \times 10^{24}$ kg due to its motion around the sun at a radius $r_\oplus = 1.5 \times 10^{11}$ m to be quantized according to Bohr's relation $L = nh/2\pi$. What is the value of the quantum number n? Could such quantization be detected? [10]

Headstart for next week, Week 07, starting Monday 2004/11/01:
– Review Section 2.3.6 "The Schrödinger equation" in "Simple Nature" by Crowellk
– Read Chapter 5 "Schroedinger's Theory of Quantum Mechanics" in Eisberg & Resnick
– – Section 5.1 "Introduction"
– – Section 5.2 "Plausibility Argument Leading to Schroedinger's Equation"
– – Section 5.3 "Born's Interpretation of Wave Functions"