Physics 202H - Introductory Quantum Physics I — Homework #05

Fall 2004 — Due 5:01 PM, Monday 2004/10/18

[55 points total]

“Journal” questions. Briefly share your thoughts on the following questions:
– Have you ever noticed any physics (or science or math or technology if you cannot recall a physics example) issue/idea/result presented incorrectly in the general media or popular press? In a non-science course? What was it? What, if anything, should be done about this type of problem? Is it a problem? Why or why not?
– Any comments about this week's activities? Course content? Assignment? Lab?

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1. (From Eisberg & Resnick, Q 4-3, pg 119) List objections to the Thomson model of the atom. Limit your discussion to about 50 words or so. [10]

2. (From Eisberg & Resnick, P 3-17, pg 82) Electrons incident on a crystal undergo refraction due to an attractive potential of about 15 V that crystals present to electrons (due to the positive ions in the crystal lattice). If the angle of incidence of an electron beam is 45°, and the electrons have an incident energy of 100 eV, what is the angle of refraction? [10]

3. (From Eisberg & Resnick, P 3-18, pg 82) What accelerating voltage would be required for electrons in an electron microscope to obtain the same ultimate resolving power as that which could be obtained from a “γ-ray microscope” using 0.2 MeV γ rays? [10]

4. (From problem 2-20, “Simple Nature”, Crowell, pg 105) Use the Heisenberg uncertainty principle to estimate the minimum velocity of a proton or neutron in a ^{208}Pb nucleus, which has a diameter of about 13 fm (1 fm = 10^{-15} m). Assume that the speed is non-relativistic, and then check at the end whether this assumption was warranted. [10]

5. (From Eisberg & Resnick, P 4-8, pg 121, with modifications)
   (a) Show that the fraction of α-particles scattered by an angle Θ or larger in Rutherford scattering is [10]
   $$f = \left(\frac{1}{4\pi\epsilon_0}\right)^2 \pi\rho t \left(\frac{zZe^2}{Mv^2}\right)^2 \cot^2(\Theta/2).$$
   (b) What fraction of 5.59 MeV α-particles from the decay of ^{222}Rn, incident on a gold foil of thickness 1 μm, will be deflected by an angle of $\pi/2$ rad or larger? [5]

Headstart for next week, Week 06, starting Monday 2004/10/18:
– Read Chapter 2.4 “The Atom” in “Simple Nature” by Crowellk
– Read Chapter 4 “Bohr's Model of the Atom” in Eisberg & Resnick
– – Section 4.5 “Bohr's Postulates”
– – Section 4.6 “Bohr's Model”
– – Section 4.7 “Correction for Finite Nuclear mass”
– – Section 4.8 “Atomic Energy States”
– – Section 4.9 “Interpretation of the Quantization Rules”
– – Section 4.10 “Sommerfeld's Model”
– – Section 4.11 “The Correspondence Principle”
– – Section 4.12 “A Critique of the Old Quantum Theory”