PHYS 102- Concepts of Physics II- Spring 2007
Homework #4
Due in class Wednesday April 18th

You must mostly type the text part of your work. But hand-write equations and drawings as needed; just please be neat. [Late work will not be carefully graded, but will be given a moderate amount of credit if it's generally satisfactory. If submitting late work, you must keep a back-up copy for yourself.]

---

1. The point of this problem is to show that nuclear reactions release much more energy than chemical reactions.

   (a) What is the difference between a chemical reaction and a nuclear reaction?
   (b) Look up TNT, in a dictionary or other source. What do these letters stand for?
   (c) The explosion of TNT is an example of a chemical reaction. In the process, about 4×10^9 Joules per ton of TNT are released (this number becomes more interesting in relation to atomic and hydrogen bombs, which we will study soon). Convert this number into Joules per kilogram. (Use 1 ton = 2000 pounds.)
   (d) As an example of a nuclear reaction, we will take the following fusion reaction:

$$^2\mathrm{H} + {}^2\mathrm{H} \rightarrow {}^3\mathrm{H} + \mathrm{H}$$

   In order to find the energy released by this reaction, compare the total mass on the left side to the total mass on the right side. You will need the following information:

mass of hydrogen atom	1.007825 amu
mass of deuterium atom	2.014102 amu
mass of tritium atom	3.016049 amu

   where "amu" (or sometimes just "u") means "atomic mass unit" and is equal to 1.660559×10^{-27} kg.

      (i) What is the total mass on the left side in kg?
      (ii) What is the total mass on the right side in kg?
      (iii) What is the mass decrease?

   (e) The fact that the mass has decreased means that energy is released by the reaction. Using Einstein's famous equation, calculate the energy released per reaction, in Joules.
   (f) For every kilogram of deuterium, there will be about 1.5×10^{26} reactions. Therefore, how much energy will be released by 1 kilogram of deuterium?
   (g) Comparing your answers to parts (f) and (c), by what factor (ratio) is the energy released in the nuclear reaction greater than the energy released in the chemical reaction? (This is a typical number, which shows the tremendous energy release from nuclear reactions.)

2. ^{6}He undergoes beta decay. Write the reaction equation, and determine the identity of the daughter nucleus. Be sure to explain your answer.

3. ^{210}Po undergoes alpha decay. Write the reaction equation, and determine the identity of the daughter nucleus. Be sure to explain your answer.
4. ^{107}Ag* undergoes gamma decay. Write the reaction equation, and determine the identity of the daughter nucleus. Be sure to explain your answer.

5. The following is a possible fission reaction. Determine the identity of the missing nucleus. Be sure to explain your answer.

$$ {}^{1}_{0}\mathrm{n} + {}^{235}_{92}\mathrm{U} \rightarrow {}^{236}_{92}\mathrm{U}^{*} \rightarrow {}^{143}_{57}\mathrm{La} + ? + 3{}^{1}_{0}\mathrm{n} $$

6. Suppose you have only 100 atoms of a certain radioactive substance. Approximately how many atoms will remain in their original state (won't have undergone radioactive decay) after 4 half-lives? Will there be precisely that many? Explain.

7. Visit the U.S. Army's White Sands Missile Range web page at http://www.wsmr.army.mil/ The Trinity Atomic Bomb test site is contained within that test range. Look under "Public Affairs" and click on "Trinity Site." Just generally poke around for a few minutes and then answer these:

   (a) Read Einstein's letter to FDR and summarize it briefly.
   (b) When is the next public open house for visits to the Trinity site? How much radiation exposure would you suffer if you went there? Is it dangerous?
   (c) Find the photo of the explosion 15 seconds after triggering and describe it briefly. About how far would sound have travelled in that amount of time? What would observers stationed 10 miles from the bomb have experienced (i.e. observed with their senses) during the 0-15 seconds after triggering?

8. This question involves checking a friend's vision. If your friend wears glasses or contact lenses you may perform this test with them on, or removed--it's your choice.

(a) Draw or print four or five letters on a white sheet of paper. Make each about the same size, and with about the same line thickness, as the letter **E** below. (This is "Verdana" size 72 font on Microsoft Word.) What letters did you choose?

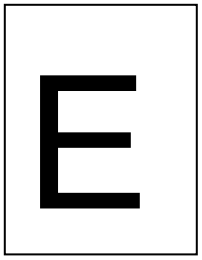
(b) Include the actual drawing or printout from part (a) as the last page of your homework. No credit for this part unless you include it.

(c) Measure the thickness of the lines that make up your letters, in millimeters.

(d) Based on what you learned in class, at what maximum distance away from your drawing could a person with normal vision be, and still confidently read your letters? Calculate this first in millimeters, and then convert to feet. We will call this your calculated distance.

(e) Now you are ready to test your friend. Tape your drawing to a wall, and have your friend start far away (at least twice your calculated distance). Then have your friend walk slowly toward the drawing, until he or she can confidently read the letters. We will call that distance your measured distance, which must be in feet.

(f) Calculate your friend's vision as follows:



$$x = 20 \cdot \left(\frac{\text{calculated distance}}{\text{measured distance}} \right)$$

Subject has $\frac{20}{x}$ vision.

(g) Does your answer make sense, based on what your friend knows about his or her vision? Briefly explain.