War & Peace Cluster, Summit Program, Physics section
Assignment 3

Notes:

Please write your answers on a separate sheet. There is not enough room between the questions. In all assignments you should keep in mind the GE goals, and in particular the goal referring to communication. It requires that a complete answer to a question requires not only the final result, but also the justification for that result. Mathematics is just another language, and showing the details of a calculation is nothing more than supporting your final conclusion.

Information:

All of the questions below rely on the formula for finding the fraction of parent nuclei remaining after some time has elapsed

$$f = e^{-kt}$$

in which f is the fraction which is any of the remaining nuclei (N), remaining mass (m), or activity (A) as a fraction of the initial value. The decay constant is k, which can always be found by looking up the half life ($T_{½}$) and then using $k = \ln(2) / T_{½}$. Just one note; the half life and the time (t) have to have the same units.

Questions:

1. The radioactive isotope ^{84}Br has a half life of 31.8 minutes.
   a. How long will it take for only ⅛th of the original sample to remain? *Note: for this question you ought to be able to count some number of half lives.*
   b. How long will it take for 1/16th of the original sample to remain?
   c. Calculate the decay constant.
   d. How long will it take for 4% of the original sample to remain?
   e. How much longer than the answer in part d) will it take for 2% of the original sample to remain? (Hint: - this should require no new calculations.)

2. At the end of the book "*On the Beach*" (which you will be reading as the first assigned book for the English portion of the class in the fall) the Earth is contaminated on a global scale by ^{60}Co (a β^- emitter) by the use of cobalt bombs.

   Suppose that in your little region of southern Australia (the setting for the book) the activity of the contamination at the end of the book is 10^{11} electrons per second. The recommended safe exposure is determined to be 1.5×10^8 electrons per second.
   a. Look up the half life of ^{60}Co.
   b. Calculate the decay constant.
   c. How long will any survivors have to wait for the activity to drop to a safe level?

3. Potassium Argon dating[1]. ^{40}K is a radioactive isotope of potassium, with ^{40}Ar being the daughter isotope. ^{40}Ar itself is stable. Molten rock contains no argon, which being a gas escapes into the atmosphere. However, after the rock has solidified it traps any argon produced by the decay of ^{40}K. If we measure the amounts of ^{40}K and ^{40}Ar in a sample of igneous rock that will tell us the age of the rock, that is the time when the rock solidified. This is the equivalent of carbon dating, which can only be used to date organic material, not rocks. The procedure is the same.

   a. Look up the half life of ^{40}K, and calculate its decay constant.

   Since you know that every ^{40}Ar atom originally came from ^{40}K, the total number of both atoms currently present in the rock must equal the number of ^{40}K atoms originally present. From that number, the number of ^{40}K atoms still remaining, and the decay curve equation you can get the age of the rock.

   b. Suppose that in a given sample of rock you now measure one ^{40}Ar atom for each ^{40}K atom. How long ago did the rock solidify? (hint: first ask how many of the original ^{40}K atoms are still ^{40}K atoms.)
   c. Suppose that a different sample of rock has only one ^{40}Ar atom for every four ^{40}K atoms. How long ago did that sample of rock solidify? (see the hint from part b)

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1 http://archserve.id.ucsb.edu/courses/anth/fagan/anth3/Courseware/Chronology/09_Potassium_Argon_Dating.html