

22.S902 IAP 2015 (DIY Geiger Counters), Problem Set 1

Due January 7th in class

January 6, 2015

1 (15 points) Radioactive Bakery

Explain, in your own words, your answer to the "radioactive cookie" problem we posed in class (slide 2). Assume all cookies have the same activity, and particles are emitted with the same energy.

2 (15 points) Heavy Metals

Using the KAERI Table of Nuclides, predict the average atomic mass of uranium. How close are you to a published value (cite your source)?

3 (40 points) Basements of Doom

Radon accumulates in basements throughout the world. It principally comes from Radium-226, occurring naturally in rocks such as granite.

1. Write the nuclear reactions for all possible decay routes of Ra-226 to Rn-222, accounting for only the two most likely alpha emission reactions.
2. Why are the relative intensities of the 4.601 MeV alpha particle and its corresponding 186 keV gamma ray different? Which mechanism accounts for this? You may want to revise your answer to problem 3.1 based on this answer...
3. Now accounting for all possible alpha decays (including the very unlikely ones), sketch the expected electron energy spectrum from Ra-226 if one had a perfect electron detector. You may want to look at page 71 of Turner's book (the Radiation Decay Chains reading) for an example.
4. Where geographically in the U.S. do you expect the danger of Radon to be the highest, and why? Do you expect the same levels of radon exposure to be present in Singapore? Show quantitative statistics or maps to support your answer, and cite your sources.

4 (30 points) Old Sources

1. How long will it take for the source in a smoke detector to degrade to 10% of its strength? How many 9V batteries will it go through in the meantime?
2. Using the printed activities, half lives, and dates on our five sources, what are the activities of the sources today? Account for imprecision in the date stamp.
3. Besides imprecision on the date, what other sources of error do you expect to encounter in determining the precise activity of a source?

Table 1: Initial Source Activities

Isotope	Type	Starting Activity	Date Stamp
^{60}Co	γ	$1\ \mu\text{Ci}$	Mar. 2011
^{60}Co	γ	$8.5\ \mu\text{Ci}$	Mar. 18, 1984
^{137}Cs	γ	$7.5\ \mu\text{Ci}$	Dec. 11, 1984
^{204}Tl	β^-	$1\ \mu\text{Ci}$	Mar. 2011
^{40}K (KCl)	γ	???	Dawn of Time

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