# <u>Radiometric dating and half-life calculations</u>

**Radiometric Dating:**

Geologists have calculated the age of Earth at 4.6 billion years. But for humans whose life span rarely reaches more than 100 years, how can we be so sure of that ancient date?

It turns out the answers are in Earth's rocks. Even the Greeks and Romans realized that layers of sediment in rock signified old age. But it wasn't until the late 1700s -- when Scottish geologist James Hutton, who observed sediments building up on the landscape, set out to show that rocks were time clocks -- that serious scientific interest in geological age began. Before then, the Bible had provided the only estimate for the age of the world: about 6,000 years, with Genesis as the history book.

Hutton's theories were short on evidence at first, but by 1830 most scientists concurred that Noah's ark was more allegory than reality as they documented geological layering. Using fossils as guides, they began to piece together a crude history of Earth, but it was an imperfect history. After all, the ever-changing Earth rarely left a complete geological record. The age of the planet, though, was important to Charles Darwin and other evolutionary theorists: The biological evidence they were collecting showed that nature needed vastly more time than previously thought to sculpt the world.

A breakthrough came with the discovery of radioactivity at the beginning of the 1900s. Scientists discovered that rocks could be timepieces -- literally. Many chemical elements in rock exist in a number of slightly different forms, known as isotopes. Certain isotopes are unstable and undergo a process of radioactive decay, slowly and steadily transforming, molecule by molecule, into a different isotope. This rate of decay is constant for a given isotope, and the time it takes for one-half of a particular isotope to decay is its radioactive half-life. For example, about 1.5 percent of a quantity of Uranium 238 will decay to lead every 100 million years. By measuring the ratio of lead to uranium in a rock sample, its age can be determined. Using this technique, called radiometric dating, scientists are able to "see" back in time.

# HALF-LIFE CALCULATIONS

Name ____________________

Half-life is the time required for one-half of a radioactive nuclide to decay (change to another element). It is possible to calculate the amount of a radioactive element that will be left if we know its half-life.

**Example:** The half-life of Po-214 is 0.001 second. How much of a 10 g sample will be left after 0.003 seconds?

**Answer:** Calculate the number of half-lives:

$$0.003 \text{ seconds} \times \frac{1 \text{ half-life}}{0.001 \text{ second}} = 3 \text{ half-lives}$$

After 0 half-lives, 10 g are left.
After 1 half-life, 5 g are left.
After 2 half-lives, 2.5 g are left.
After 3 half-lives, 1.25 g are left.

Solve the following problems.

1. The half-life of radon-222 is 3.8 days. How much of a 100 g sample is left after 15.2 days?

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2. Carbon-14 has a half-life of 5,730 years. If a sample contains 70 mg originally, how much is left after 17,190 years?

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3. How much of a 500 g sample of potassium-42 is left after 62 hours? The half-life of K-42 is 12.4 hours?

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4. The half-life of cobalt-60 is 5.26 years. If 50 g are left after 15.8 years, how many grams were in the original sample?

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5. The half-life of I-131 is 8.07 days. If 25 g are left after 40.35 days, how many grams were in the original sample?

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6. If 100 g of Au-198 decays to 6.25 g in 10.8 days, what is the half-life of Au-198?

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