

Radioactive Decay Calculations (no calculators)

The table shows just a few of the many different isotopes that can be used to determine absolute ages of objects.

Isotope	Half-Life
Uranium-238	4.5 billion years
Potassium-40	1.3 billion years
Plutonium-239	25000 years
Carbon-14	5730 years
Californium-249	360 days
Nobelium-259	1.5 hours
Lawrencium-260	180 seconds

1. Hazardous radioactive waste is considered "safe" after approximately 10 half-lives have passed. Approximately what percent of a radioactive parent remains after 10 half-lives?

$100\% \xrightarrow{1} 50\% \xrightarrow{2} 25\% \xrightarrow{3} 12.5\% \xrightarrow{4} 6.25\% \xrightarrow{5} 3.1\% \xrightarrow{6} 1.5\% \xrightarrow{7} 0.75\% \xrightarrow{8} 0.38\% \xrightarrow{9} 0.19\% \xrightarrow{10} 0.08\%$

(0.1% parent remains)

2. Plutonium-239 is just one of the hazardous wastes from nuclear power plants. Approximately how long does it have to be stored away from humans?

10 half lives = (10) 25000 = 250,000 yrs.

3. You have a sample of rock that you suspect is somewhere in the age range of 3.0-3.5 billion years. Would you choose to measure C-14 to determine the actual rock age? Why or why not?

Would not choose C-14
 C-14 effectively decayed after 10 half lives (~ 57300 yr)

4. You have a lava sample that contains 7.5 grams of Californium-249 and 52.5 grams of its daughter product. How old is the lava sample?

$$\begin{array}{r} 7.5 \text{ g. parent} \\ 52.5 \text{ g daughter} \\ \hline 60.0 \text{ g orig. parent} \end{array}$$

$$60.0 \text{ g} \xrightarrow{1} 30 \text{ g} \xrightarrow{2} 15 \text{ g} \xrightarrow{3} 7.5 \text{ g parent}$$
 3 half lives x 360 days = 1080 days

5. The half-life of copper-60 is 2.4 minutes. How many grams of Cu-60 in 8.0 g sample will remain undecayed after 7.2 minutes?

$\frac{7.2 \text{ min}}{2.4 \text{ min/half life}} = 3 \text{ half lives}$
 $8.0 \text{ g} \xrightarrow{1} 4.0 \text{ g} \xrightarrow{2} 2.0 \text{ g} \xrightarrow{3} 1.0 \text{ g parent Cu-60 undecayed}$

6. You find a wood fragment during a village excavation in Tibet. Your analysis shows that C-14 has been reduced to 25% of the amount the tree had when it was alive. How old is the wood fragment?

$100\% \xrightarrow{1} 50\% \xrightarrow{2} 25\%$
 2 half lives x 5730 yrs = 11460 yrs old

7. You find a human bone during an archeological dig. Your analysis shows the following C-14 and N-14 concentrations: 40g C-14 and 280g N-14. How old is the bone?

$$\begin{array}{r} 40 \text{ g parent} \\ 280 \text{ g daughter} \\ \hline 320 \text{ g orig. parent} \end{array}$$
 $320 \text{ g} \xrightarrow{1} 160 \text{ g} \xrightarrow{2} 80 \text{ g} \xrightarrow{3} 40 \text{ g parent}$
 3 half lives x 5730 yrs. = 17190 yrs. old