SPH3U UNIVERSITY PHYSICS

ENERGY & SOCIETY

- Half-Life (P.330-333)

Nuclear Decay

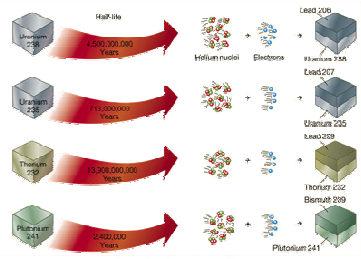
In 1911, a young university student used his knowledge of radioactive chemicals to solve a problem in a boarding house. He suspected that the cook was using food left over from one day to prepare meals for later in the week. Unaware of the health hazards, the student spiked the uneaten left-overs with radioactive lead to test his hypothesis. He knew that radioactivity is not affected by temperature or chemicals.

Nuclear Decay

Several days later the same dish was served. The student put a sample into a bag, took it to the laboratory and tested it. Sure enough, the cook had recycled the leftover food. The student confronted the cook with the evidence. The cook claimed that the student was practising magic and that magic was against house rules. The student was evicted from the boarding house!

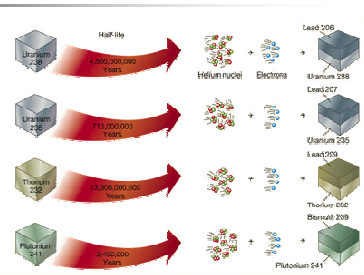
Half-Life

Nuclear decay reactions are spontaneous. There is no way to predict when a particular unstable nucleus will disintegrate. However, it is possible to predict the decay rate for a large sample of an isotope.



Half-Life

Radioactive materials decay at different rates, which can vary significantly, from fractions of a second to millions of years. The average length of time it takes a radioactive material to decay to half its original mass is called the ***half-life****.*



Half-Life

HALF-LIFE

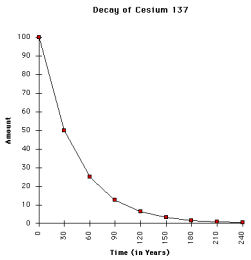
- average length of time it takes a radioactive material to decay to half its original mass
- can vary from fractions of a second to millions of years

NOTE!

The half-life of any given isotope is actually an <u>average time</u> for an atom to decay. Cobalt-60, for example, has a half-life of 5.27 years. This does not mean that every atom of this isotope decays after 5.27 years. Some atoms decay sooner, and some later. On average, however, it takes 5.27 years for a coblat-60 atom to decay. The larger the sample size, the more accurately a material decays according to its half-life.

Half-Life

Radioactive decay is an example of an exponential relationship – as time increases the mass of a radioactive isotope remaining in the sample decreases at an exponential rate. The rate of decay is greater in the initial stages of the process because there are more atoms to decay. However, the rate of decay continuously decreases as the sample gets smaller and smaller.

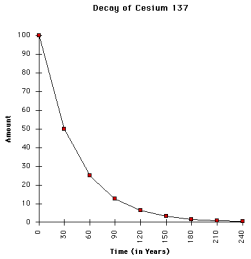


Half-Life

PRACTICE

1. According to the graph what is the half-life of cesium-137?

   $t_{half\text{-}life}$ = 30 years



Applications of Half-Life – Carbon Dating

The half-life of carbon-14 is 5730 years. It decays into nitrogen-14 according to the following nuclear reaction equation:

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

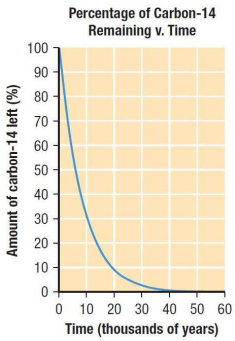
The half-life of C-14 makes it a useful material for measuring the age of organisms that once lived long ago. When plants absorb carbon dioxide through the process of photosynthesis, the carbon is typically a mixture of the common C-12 and the relatively rare C-14 isotopes. Herbivores ingest C-14 when they eat plants, and carnivores do so when they feed on herbivores. The ratio of C-14 to C-12 is generally constant and equal in all living things.

Applications of Half-Life – Carbon Dating

When an organisms dies, however, it no longer consumes food, and therefore no long ingests carbon. As the carbon-14 decays, the C-14 to C-12 ratio in the dead organism is reduced by half every 5730 years. Scientists can use this known rate of decrease to determine when the organism died.

NOTE!

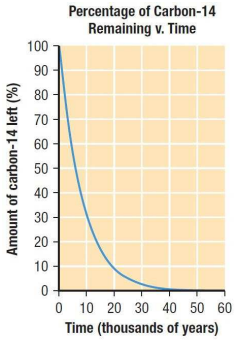
Other isotopes, such as aluminum-26 and magnesium-26, are also useful for dating objects and organisms.



Applications of Half-Life – Carbon Dating

APPLICATIONS OF ...

- the decay of a radioactive isotope can be mathematically modelled
- isotopes such as carbon-14 can be used to date fossils and other archaeological objects



Applications of Half-Life – Carbon Dating

PRACTICE

2. According to the graph how much time will pass before 10% of the original C-14 remains?

$t_{10\%}$ ~ 20 thousand years