Physics with Synno – Matter – Lesson 7

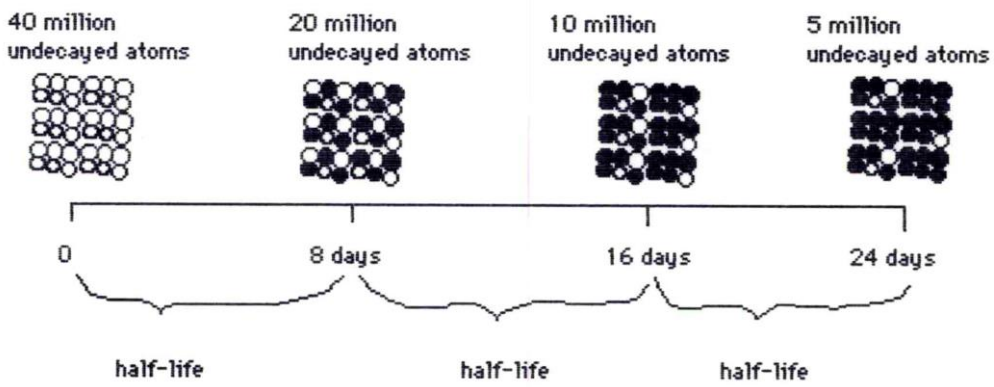
M.6 Half-Life

Video: Bill Nye Explains Half Life
Half-life and Radioactivity

Different nuclei will emit radiation and decay at different rates. The decay rate is not affected by physical or chemical conditions e.g. temperature, pressure.
The time required for the decay of $^1/_2$ of the original sample is called the half-life of the material.

i.e. The half-life of a radioactive isotope is the time taken for half the nuclei (atoms) present to decay into another element.

eg. iodine-131 has a half-life of 8 days. If we start with a sample of 40 million iodine atoms then over time the following will happen.

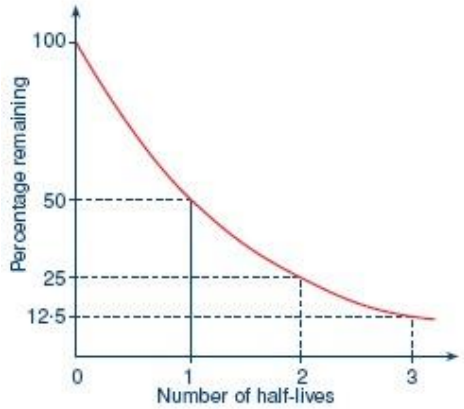


The formula that can be used in half-life calculations is

$$N = N_0 \left(\frac{1}{2}\right)^n$$

where n = no. of half-lives
N_o = original number of atoms
N = final number of atoms

Note: N and N_o can be substituted by
Mass - m and m_o (in gm)
Activity (decay rate) - A and A_0 (in Bq) (Becquerel)
1 Bq = 1 decay per second



The amount of the original isotope halves as each half-life passes. This is an exponential relationship.

Some common radioisotopes, their half-lives and applications

Isotope	Emission	Half-life	Application
Natural			
Polonium-214	α	0.00016 seconds	Nothing at this time.
Carbon-14	β	5730 years	Carbon dating of fossils
Uranium-235	α	700 000 years	Nuclear fuel, rock dating
Uranium-238	α	4500 million years	Nuclear fuel, rock dating
Artificial			
Technetium-99m	β	6 hours	Medical tracer
Sodium-24	β	15 hours	Medical tracer
Iodine-131	β	8 days	Medical tracer
Phosphorus-32	β	14.3 days	Medical tracer
Cobalt-60	γ	5.3 years	Radiation therapy
Americium-241	α	460 years	Smoke detectors
Plutonium-239	α	24 000 years	Nuclear fuel, rock dating

Note: The half-life pattern applies to a large number of atoms.

Individual atoms have two options → Decay / Not decay

Thus the probability of a particular atom decaying is ½

Example 1

A sample of the radioisotope thorium-234 contains 8.0×10^{12} nuclei. The half-life of ^{234}Th is 24 days. How many thorium-234 atoms will remain in the sample after:

a) 24 days? 1 half-life → 4.0×10^{12}
b) 48 days? 2 half-lives → 2.0×10^{12}
c) 96 days? 4 half-lives → 0.5×10^{12}

Example 2
Strontium-82 has a half-life of 25.0 days. If you started with 160 g of Strontium-82, in how many days would you have only 10 g left?

160g → 80g → 40g →20g → 10g is 4 Half-lives. Thus 4 × 25 = 100 days

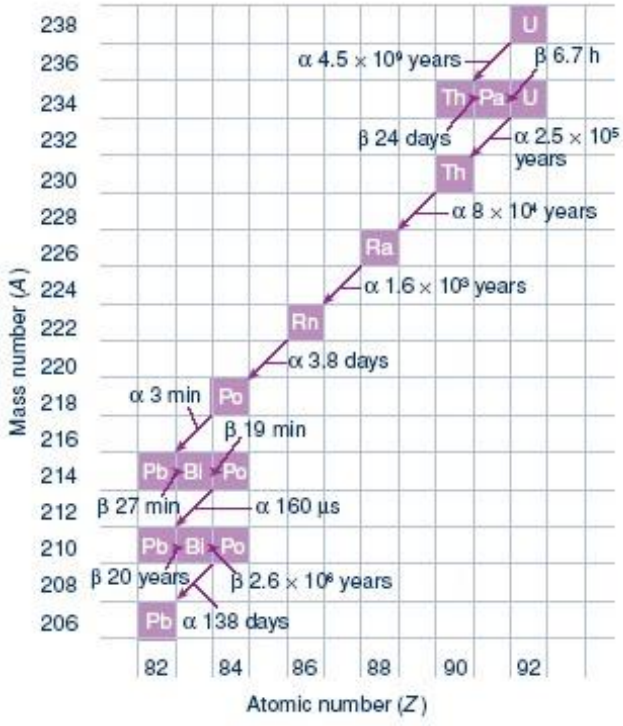
Example 3
In 2 hours, the activity of a sample of a radioactive element falls from 240 Bq to 30 Bq. What is the half-life of this element?

240 → 120 → 60 → 30 is 3 Half-lives. Thus 3 × 2 = 6 hours

M.6.1 Decay Series

Video: U-238 Isotopic Decay Series

Scientists noticed that many of the products produced by radioactive decay are themselves radioactive. They were able to identify a series of radioactive nuclides that were formed before a stable end product was reached. The end product of many of these series is ${}_{82}Pb$.



Problem Set #7: Text Page 222 All Questions