Radioactive decay rates

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Half life

- The eventual decay of any particular radioactive atom is random - we can not know when it will decay.
- The **half life** of an isotope is the time that it takes for half of the atoms to decay.
- For example uranium-235 has a half live of around 700,000 years. This means that there is a 50/50 chance that a particular atom will decay in the next 700,000 years.
- Half of the uranium-235 atoms would be expected to decay in that time.
- Every radioisotope has a unique half-life. Some are as short as a nanosecond, some are measured in billions of years.

Examples of isotopes & half-lives

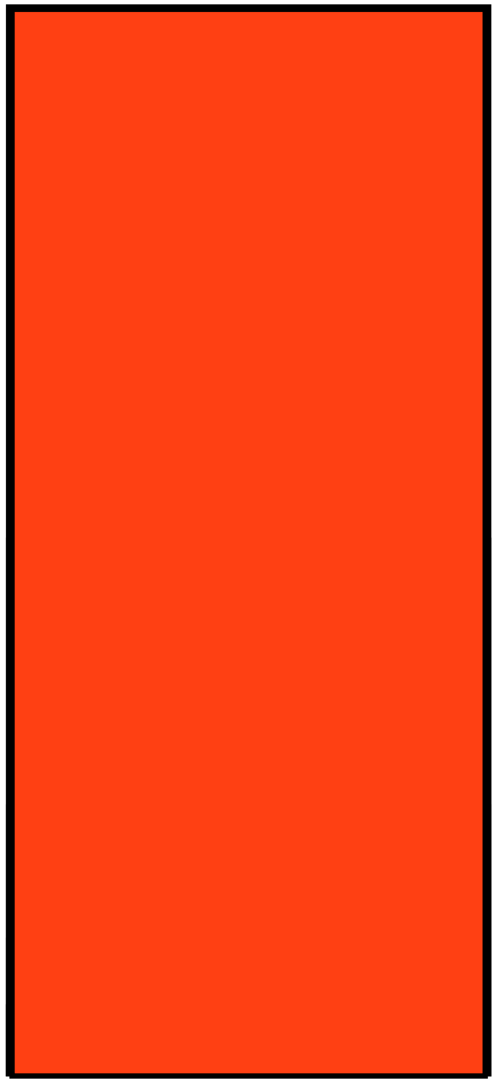
Isotope	Half-life	Use
Thorium-232	1.4×10^{10} years	Rock & fossil dating
Uranium-235	7.0×10^{5} years	Nuclear fuel
Cobalt-60	5.3 years	Radiation therapy
Beryllium-8	7.0×10^{-17} seconds	????

Calculating with half-lives

- For example, carbon 14 has a half live of 5700 years.
- Starting with 1.00 grams:

Time (years)	n (half lives)	Fraction	Amount (grams)
0	0	1	1.00
5,700	1	1/2	0.50
11,400	2	1/4	0.25
17,100	3	1/8	0.13
22,800	4	1/16	0.06

Carbon 14



Radioactive decay

Half-life equations

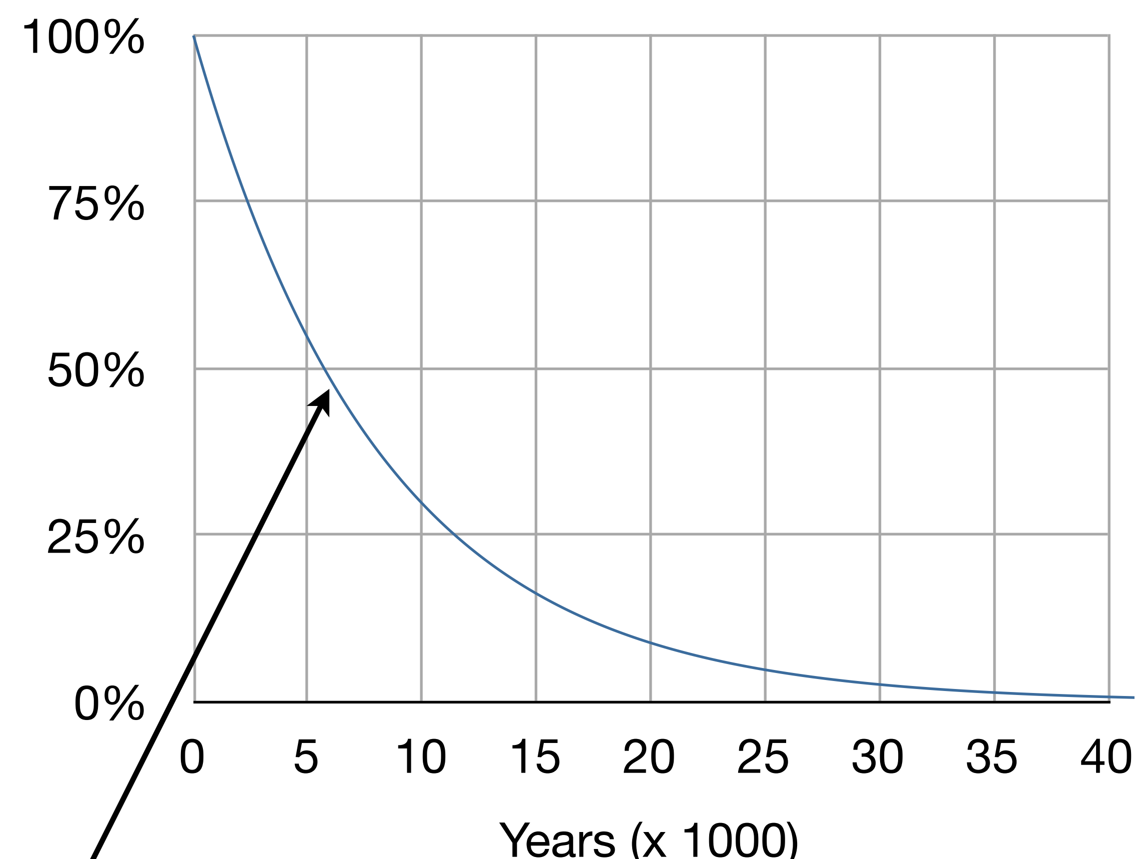
- After each half-life has passed, the amount of the radioisotope present has halved.
- This can be modelled using an exponential equation - this equation uses powers of half.

n = number of half-lives

$$N = N_O \times \left(\frac{1}{2}\right)^n \qquad n = \frac{t}{t_{\frac{1}{2}}}$$

N_O = number of atoms at time t = O.

Carbon-14: amount vs time



Half life ~ 5700 years

Half-life calculations

Cobalt-60 has a half life of ~5.3 years.
a) Find the fraction remaining after 10.6 years.
b) Find the amount remaining after 20 years.
c) Find the time when there is 1/8 remaining.

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

↑ fraction remaining

$$n = \frac{t}{t_o}$$

↑ n = number of half-lives

a) $n = \frac{10.6\ years}{5.3\ years} = 2$ $\frac{N}{N_o} = \left(\frac{1}{2}\right)^2 = \frac{1}{4} = 25\%$

b) $n = \frac{20\ years}{5.3\ years} = 3.8$ $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{3.8} = 7\%$

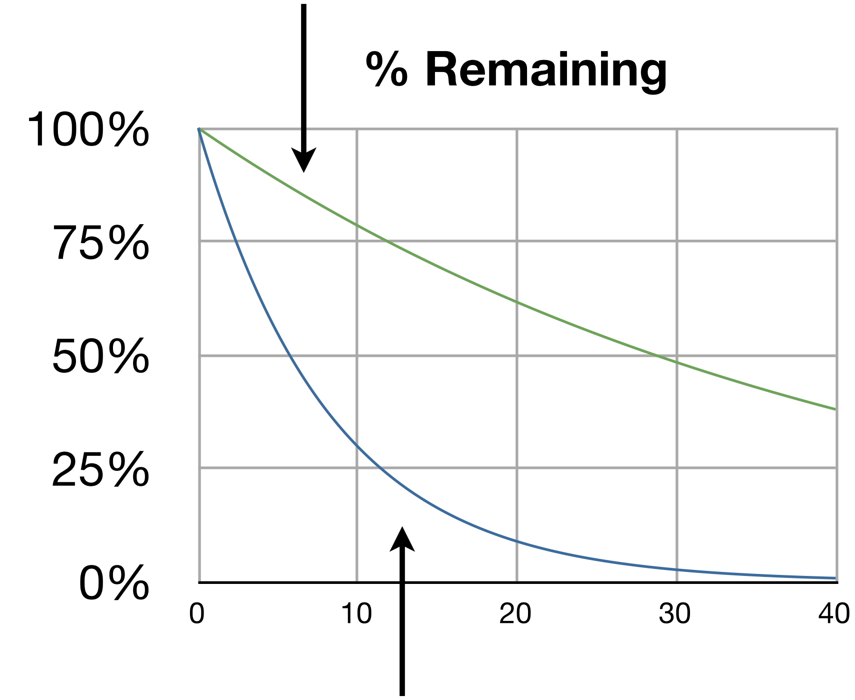
c) $n = \frac{N}{N_o} = \frac{1}{8} = \left(\frac{1}{2}\right)^n$ $n = 3,\ \ t = 15.9\ years$

$$n = \frac{log(1/8)}{log(1/2)} = 3$$

Decay rates

- Radioactive decay **rate** is measured using the **Becquerel**.
- One Bq = One decay / second.
- The rate of decay is dependent on the amount of the radioisotope: more atoms means more chance of decays occurring.
- The equations used for the mass or amount can also be used for rate.
- The decay rate will halve over the half-life of the isotope.
- Isotopes with shorter half life will decay more quickly - at a higher rate of decay.
- Long lived isotopes will release smaller amounts of radiation over a longer time period.

Longer half life = lower rate of decay



Shorter half life
= higher rate of decay