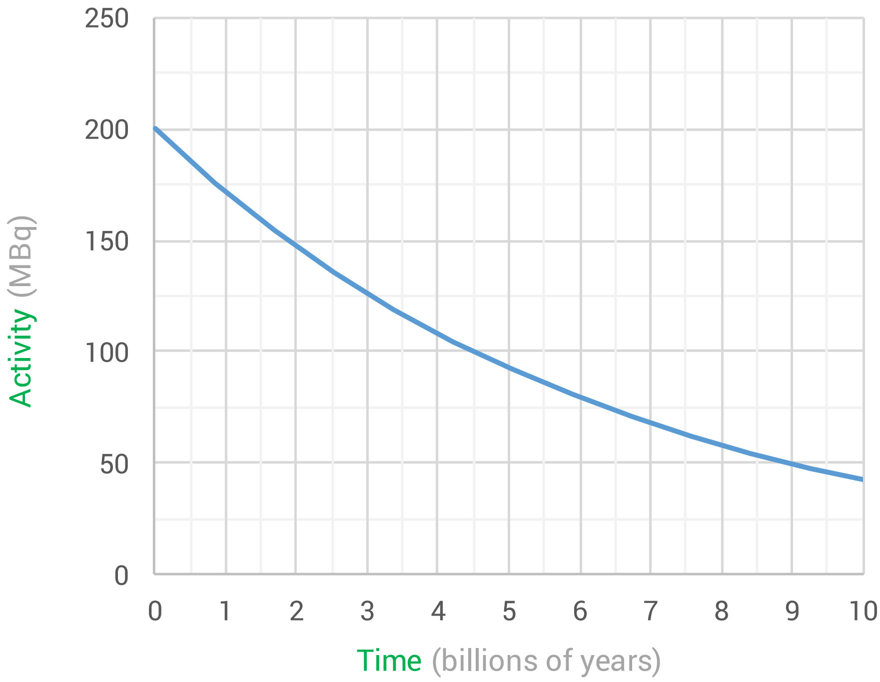
0 1

The below graph shows how the activity of a sample of uranium-238 changes with time.



0 1 . 1

The initial activity of this sample is 200 MBq (1 MBq = 10^6 Bq).
What is meant by the activity of a source?

The activity of a source tells us the number of nuclei (atoms) in a radioactive source which decay [1] per second [1].

0 1 . 2

Uranium-238 has an exceptionally long half-life.
Explain what is meant by the half-life of a substance.

The time taken for the activity of / count rate from / mass of a / number of radioactive nuclei present in a substance [1] to fall to half of its initial value [1].

0 1 . 3

Using information from the graph, determine the half-life of uranium-238.

E.g. at t = 0, A = 200 MBq
Half of initial activity = 200 ÷ 2 = 100 MBq
(From graph) time at which activity = 100 MBq is t = 4.5 billion years

Half-life = **4.5 billion years**

0	2

Techentium-99m is an important isotope in medical imaging.
The half-life of technetium-99m is 6 hours.

0 2 . 1

A fresh sample of technetium-99m is prepared in a hospital.
What fraction of this sample will have **decayed** after 18 hours?

18 hours = 3 half-lives (18 ÷ 6 = 3)
Fraction remaining after 3 half-lives = ½ × ½ × ½ = 1/8
Therefore, fraction which has decayed = 1 – 1/8 = 7/8

Answer = **7/8**

0 2 . 2

A different sample of technetium of mass 128 mg is prepared on March 3rd at midday. How much of this technetium will be remaining on March 5th at the same time?

2 days = 48 hours
48 hours = 8 half-lives (48 ÷ 6 = 8)
Mass remaining after 8 half-lives:

m = 128 ÷ 2 ÷ 2 ÷ 2 ÷ 2 ÷ 2 ÷ 2 ÷ 2 ÷ 2 (or $128 \div 2^8$) = **0.5 mg**

0 3

To estimate the age of rocks, scientists sometimes compare the amount of potassium-40 the amount of argon-40 they contain. They assume that, when the rock was just formed, it contained no argon (argon is a gas which could escape from molten rock). Potassium-40 has a half-life of 1.3×10^9 years, and it decays to form argon-40, which is stable.

0 3 . 1

The ratio of potassium-40 to argon-40 in a particular rock is 1:1.
Estimate the age of the rock.

Initially, the rock contained only potassium-40. After 1 half-life, half of the potassium-40 present will have decayed to form argon-40 (so there will be an equal number of both types of nuclei present within the rock, and their ratio will be 1:1).

Age = **1.3×10^9 years**

0 3 . 2

In a different rock, the ratio of potassium-40 to argon-40 is 1:7.
Show that it is approximately 3.9 billion (3.9×10^9) years old.

After 1 half-life, ratio = 1:1
After 2 half-lives, ratio = 1:3
After 3 half-lives, ratio = 1:7

Therefore, age of rock:

= $3 \times (1.3 \times 10^9)$ years
= **3.9×10^9 years**

> **TOP TIP:** this is probably the most difficult type of question you could be asked on this topic. If you don't like using ratios, start off with dummy figures.
>
> If there was 80 g of potassium to start with, after 3 half-lives, there would be 10 g remaining, and 70 g would have been converted to argon, so the ratio is 10:70 (which is the same as 1:7).