

Radioactive Decay

To know what activity is and how to calculate it

To know what the decay constant is and how to calculate it

To know what half life is and be able to find it by calculation or graphical methods

Decay

Something that is radioactive will decay into something that is stable. Radioactive decay happens randomly and spontaneously: there is no way of predicting when a radioactive nucleus will decay and external factors do not influence it at all (e.g. pressure and temperature).

What we can do is give a probability that a nucleus will decay in a given time.

Decay Constant, λ

Every radioactive isotope has its own probability that a nucleus will decay, called the decay constant.

Activity, A

The activity of a radioactive source is the number of decays that happen every second.

1 becquerel is equal to one decay per second, 50 becquerels is equal to 50 decay per second,

Activity is measured in becquerels, Bq (decays per second, s^{-1})

During a certain amount of time, Δt , some radioactive atoms (ΔN) decay from a sample of N atoms.

The change in the number of nuclei in a certain time is $\frac{-\Delta N}{\Delta t} = \lambda N$ this can be written as $A = -\lambda N$

The minus sign is there because we are losing nuclei, the number we have left is getting smaller.

Exponential Decay

As time passes the number of nuclei that decay every second will decrease.

To calculate the number of nuclei that we have left after a time, t , is given by:

$$N = N_0 e^{-\lambda t}$$

Where N_0 is the number of nuclei at the start and N is the current number of nuclei. This is similar to the exponential decay equation of a discharging capacitor.

The equation for calculating the activity looks similar:

$$A = A_0 e^{-\lambda t}$$

Half-Life

Each radioactive isotopes has its own half-life. We already know that it is:

The time it takes for the number of atoms in a sample to drop to half of its original sample or

The time it takes for the activity of a substance to drop to half of its original activity

Half-Life is measured in seconds, s

The half life of a substance is linked to the decay constant.

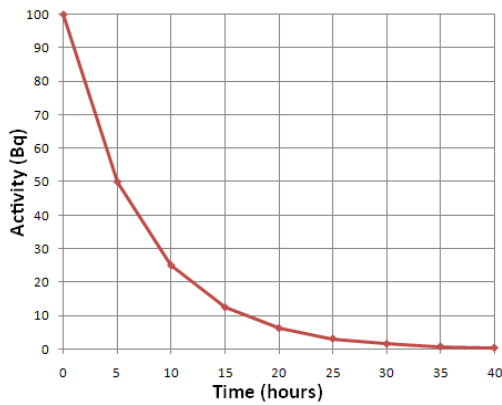
If there is a high probability that a nucleus will decay ($\lambda = \text{BIG}$) then it will not take long before half the sample has decayed to stability (half-life = short).

If there is a low probability that a nucleus will decay ($\lambda = \text{small}$) then it will take a long time for half of the sample to have decayed (half-life = LONG).

$$T_{1/2} = \frac{\ln 2}{\lambda}$$

where $T_{1/2}$ is the half life

Graphs



We can calculate the half-life from activity and number of nuclei graphs. Choose a starting value and then find how long it takes to fall to half this value. In the graphs we can see that both fall from 50 to 25 and take 5 hours to do this. Therefore the half-life is 5 hours. Knowing this we can then calculate the decay constant.

