

## 53 Half-Life

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Nuclear decay is **random**. You can not predict when an individual nucleus will **decay**. However, if you have many millions of nuclei, you can make a good prediction of how many will decay in a certain amount of time.

The **half-life** is the average time taken for the number of unstable nuclei to halve.

The half-life is also the average time taken for the **activity** (number of decays each **second**) to halve.

Example - The half-life of  ${}^3_1\text{H}$  is 12 years. A source starts with an activity of 150 Bq (150 decays per second). Estimate the activity 12 and 24 years after the start.

After 12 years, one half-life has passed, so the activity will halve to 75 Bq. After 24 years, a second half-life has passed, halving the activity again to  $75 \times 0.5 = 37.5$  Bq.

53.1  ${}^{14}_6\text{C}$  has a half-life of 5 700 years. A sample is 5 700 years old and has an activity of 200 Bq.

- (a) What was the initial activity?
- (b) What will the activity be 5 700 years in the future?

53.2 A sample starts with  $10^{16}$  nuclei of  ${}^3_1\text{H}$ , which has a half-life of 12 years.

- (a) How many  ${}^3_1\text{H}$  nuclei will this sample contain after 12 years?
- (b) How many  ${}^3_1\text{H}$  nuclei will this sample contain 24 years after the start?
- (c) How many  ${}^3_1\text{H}$  nuclei will this sample contain 36 years after the start?

53.3 These questions are about  ${}^{13}_7\text{N}$ , which has a half-life of 10 minutes.

- (a) If I start with 6 000 000 nuclei, how many will remain after 10 minutes?

- (b) If the activity was 600 Bq initially, what will it be after 30 minutes?
- (c) If the activity was 24 000 Bq initially, what will it be one hour later?

53.4 Suppose the activity of a sample of radioactive material was 100 Bq at the start. What would you divide 100 Bq by to obtain the activity

- (a) 1 half-life after the start?
- (b) 2 half-lives after the start?
- (c) 3 half-lives after the start?
- (d) 4 half-lives after the start?
- (e) 20 half-lives after the start?
- (f)  $n$  half-lives after the start?

53.5 ♡ Use your reasoning from Q53.4 to answer this. The half-life of  ${}^{13}_{7}\text{N}$  is 10 minutes. The initial activity of a sample of  ${}^{13}_{7}\text{N}$  is 100 Bq. Determine the activity 5 minutes later.