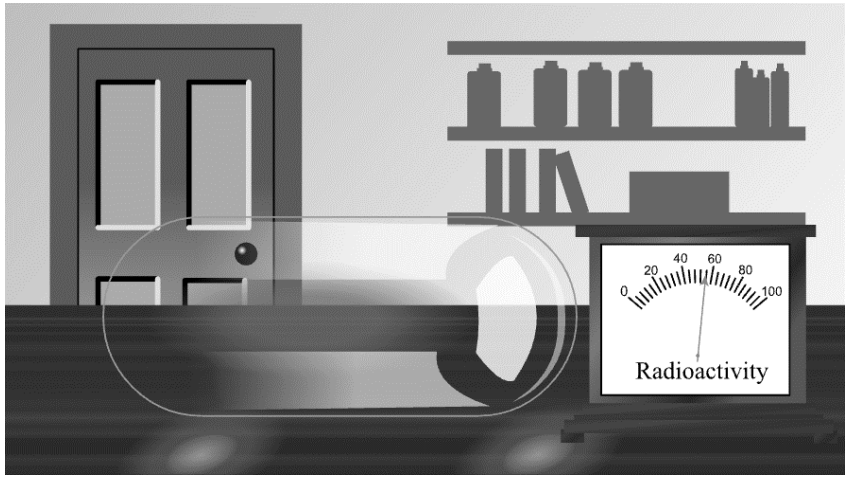
5.1 The discovery that radioactivity decreases with time

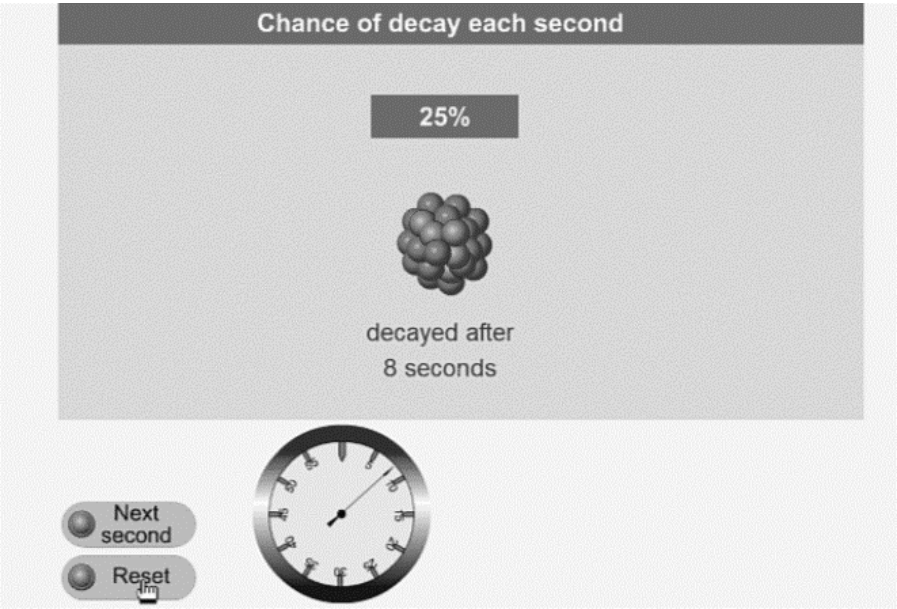
- Radioactivity always decreases with time
- Sometimes the decrease is too slow to observe



Rutherford found that thorium powder gave off a radioactive gas whose radioactivity decreased markedly with time

5.2 Stability and randomness

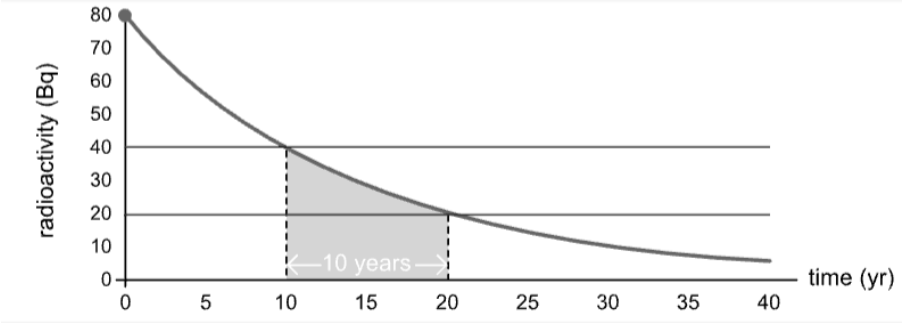
- When a nucleus 'decays' it doesn't disappear - the nucleus changes and it gives off an alpha, beta or gamma.
- Radioactive decay is random because
  - you can't tell when a given nucleus will decay
  - you can tell how many nuclei will decay each second, just not which ones



On average this kind of nucleus will decay after 4 seconds. But you can't tell when any given nucleus will decay.

5.3 Radioactivity and half-life

- Half-life is the time it takes for the radioactivity of a source to decrease by half
- Half-life is also the time for the number of undecayed nuclei to decrease by half
- A short half-life means very radioactive for a short time
- A long half-life means not very radioactive for a long time



This isotope has a half-life of 10 years because the time it takes for the radioactivity to halve is always 10 years

5.4 Half-life calculations

- You should know how to answer three types of half-life questions:
  - Calculating count rate if you know half-life
  - Calculating half-life if you know count rate
  - Calculating mass of undecayed atoms if you know half-life and time

1. A radioactive isotope has a half-life of 30 minutes.

Its initial count rate is 4800 Bq.

What will the count rate be after 2 hours?

Half-lives	0	1	2	3	4
Time (mins)	0	30	60	90	120
Count (Bq)	4800	2400	1200	600	300

Count rate after two hours = 300 Bq

All questions can be answered using this kind of table. Number of half-lives is always the first row.

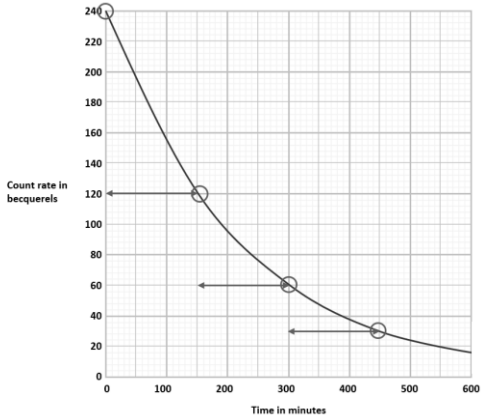
5.5 Half-life and graphs

- How to find half-life from a graph of activity vs. time
- How to find activity from a graph of undecayed nuclei vs. time

1. The count rate for a radioactive isotope was recorded for 600 minutes.

The graph shows the results after adjusting for background radiation.

What is the half-life of the isotope?

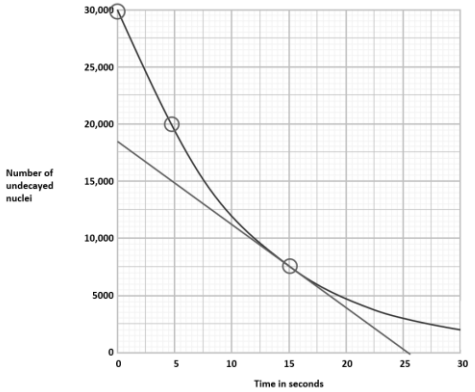


Half-life = 150 minutes

2. The graph shows how the number of undecayed nuclei of a radioactive isotope decreases with time.

a. Estimate the activity at time = 0.

b. Estimate the activity after 15 seconds.



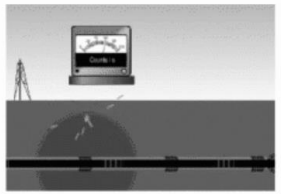
a.) Activity = change in number of nuclei / time
= (30,000 - 20,000) / 4.5
= 10,000 / 4.5
= 2220 Bq

b.) Activity = change in number of nuclei / time
= gradient of decay curve
= 18,500 / 25.5
= 725 Bq

5.6 Half-life: Radiation uses and risks

- Use a short half-life if you want an isotope to stop being radioactive quickly - like a medical or environmental tracer
- Use a long half-life if you want the radioactivity to stay fairly constant - for example a beta thickness gauge or smoke alarm
- If you're going to use a short half-life, you need to produce or isolate the isotope close to where it's going to be used, for example with beta plus emitters used in a PET scan

Hours or days



5 – 500 years