# Chapter 3 **Radioactivity and radiation**

## Module 3.5 Radiation dose and its effects on humans

### Evaluation and Analysis 3.5.1 **Data analysis:** Decay of thorium-234

**Total marks 25**

A sample of thorium-234 was placed in storage for nearly 1 year. While it was in storage its activity was monitored regularly by an automatic sensor that was placed 10 cm from the sample.

Let $N_o$ = the original number of nuclei of radioactive material.

Let $N$ = the number of nuclei of radioactive material present after $n$ half-lives have passed. Therefore, $N = \frac{N_o}{2^n}$

### Questions

1   Use the above relationship to complete the data table below.                    (3 marks)

| Time, $t$ (days) | No. of half-lives, $n$ | No. of nuclei of radioactive isotope, $N$ | Activity (Bq) 10 cm from sample |
|---|---|---|---|
| 0 | 0 | $8.0 \times 10^{10}$ | 1900 |
| 24 | 1 | $4.0 \times 10^{10}$ | |
| 48 | 2 | | |
| 72 | 3 | | |
| 96 | 4 | | |
| 120 | 5 | | |
| 144 | | | |
| 168 | | | |
| 192 | | | |
| 216 | | | |
| 240 | | | |
| 264 | | | |
| 288 | | | |
| 312 | | | |
| 336 | | | |
| 360 | | | |

2   On graph paper, produce a fully labelled graph of $N$ versus $t$.                    (4 marks)

3   What is the name for a curve of the shape shown in your graph of $N$ versus $t$?          (1 mark)

4   On graph paper, produce a fully labelled graph of activity versus time.                    (3 marks)

**5**   What is the half-life of thorium-234? (1 mark)

**6**   How many nuclei of thorium-234 decayed during the:

   **a**   first 24 days? (1 mark)

   **b**   first 96 days? (1 mark)

   **c**   last 96 days? (1 mark)

   **d**   last 24 days? (1 mark)

On the very first day, the activity of the same sample was measured at a range of distances from the source and the following results were obtained.

| Distance from source (m) | Activity (Bq) |
|---|---|
| 0.10 | 1900 |
| 0.15 | 844 |
| 0.20 | 475 |
| 0.25 | 304 |
| 0.30 | 211 |
| 0.35 | 155 |
| 0.40 | 119 |
| 0.45 | 94 |
| 0.50 | 76 |

**7**   On graph paper, plot a graph of activity versus distance from the source. (3 marks)

**8**   You are required to construct a graph that will allow you to prove that the *activity varies inversely with the square of the distance from the source*. In doing this:

   **a**   What variables and units would you put on the *y*- and *x*-axes of a graph to confirm a relationship such as activity $\propto \frac{1}{d^2}$ ? (2 marks)

   **b**   If this relationship was confirmed, what shape would the graph take? (1 mark)

   **c**   Manipulate your data and construct the graph that will allow you to prove that the activity varies inversely with the square of the distance from the source. (3 marks)