Chapter 3 **Radioactivity and radiation**

Teacher Notes

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, $N = \frac{N_0}{2^n}$

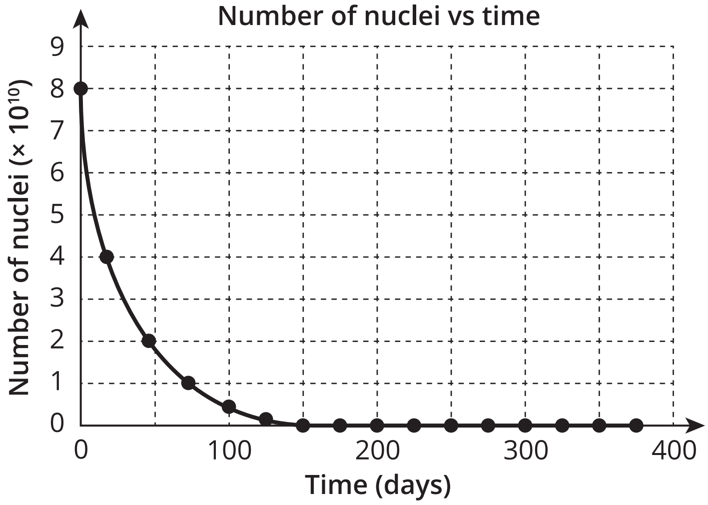
Questions

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	8.0×10^{10}	1
24	1	4.0×10^{10}	
48	2	2.0×10^{10}	475.0
72	3	1.0×10^{10}	238
96	4	5.0×10^{9}	119
120	5	2.5×10^{9}	59
144	6	1.25×10^{9}	30
168	7	6.3×10^{8}	15
192	8	3.1×10^{8}	7.4
216	9	1.6×10^{8}	3.7
240	10	7.8×10^{7}	1.9
264	11	3.9×10^{7}	0.93
288	12	2.0×10^{7}	0.46
312	13	9.8×10^{6}	0.23
336	14	4.9×10^{6}	0.12
360	15	2.4×10^{6}	0.06

 ISBN 978 1 4860 2222 9

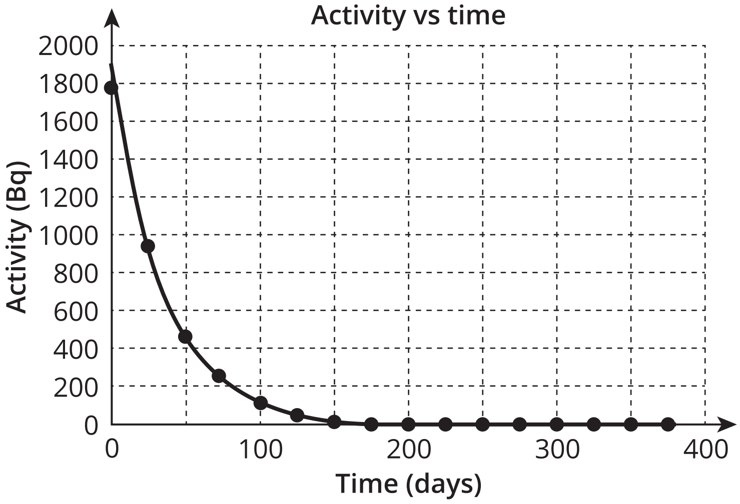
2 On graph paper, produce a fully labelled graph of N versus t.



1 mark correct labelling of axes and labelling of graph.
2 marks for accurate plotting of data (exponential decay).
1 mark for appropriate size of graph and scales used. (4 marks)

3 What is the name for a curve of the shape shown in your graph of N versus t?
This is an exponential decay curve. (1 mark)

4 On graph paper, produce a fully labelled graph of activity versus time.



1 mark for correct labelling of axes and labelling of graph.
1 mark for accurate plotting of data (exponential decay).
1 mark for appropriate size of graph and scales used. (3 marks)

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

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

a first 24 days?
$8.0 \times 10^{10} - 4.0 \times 10^{10} = 4.0 \times 10^{10}$ (1 mark)

b first 96 days?
$8.0 \times 10^{10} - 5.0 \times 10^{9} = 7.5 \times 10^{10}$ (1 mark)

c last 96 days?
$3.9 \times 10^{7} - 2.4 \times 10^{6} = 3.7 \times 10^{7}$ (1 mark)

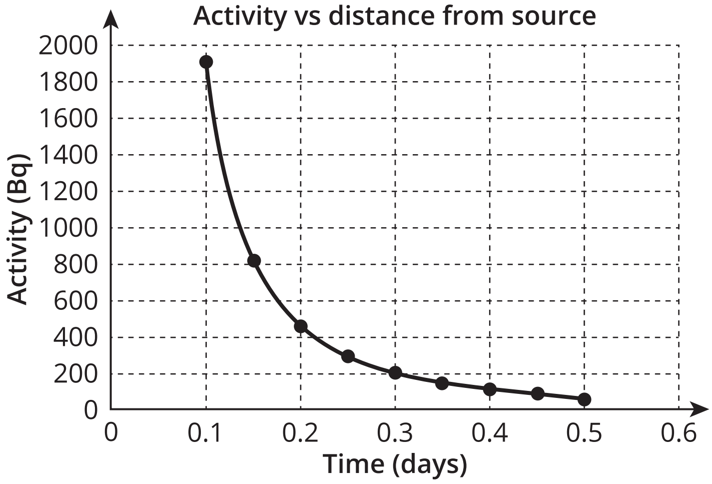
d last 24 days?
$4.9 \times 10^{6} - 2.4 \times 10^{6} = 2.5 \times 10^{6}$ (1 mark)

 ISBN 978 1 4860 2222 9

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.



1 mark for correct labelling of axes and labelling of graph.

1 mark for accurate plotting of data (inverse square relationship).

1 mark for appropriate size of graph and scales used. (3 marks)

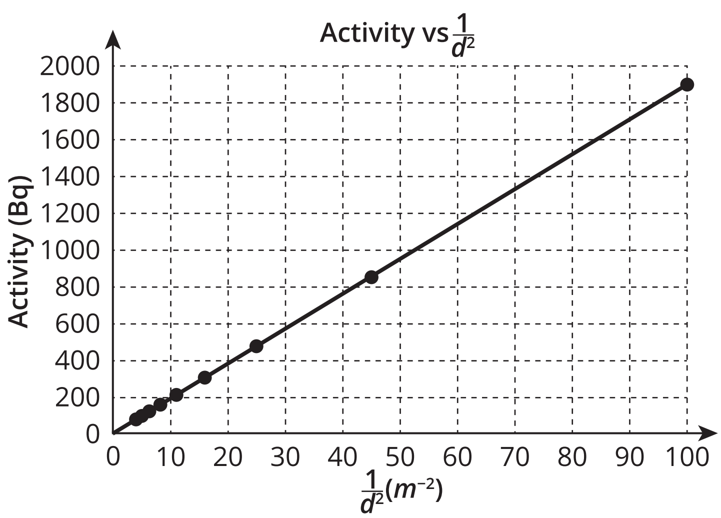
8 You are required to construct a graph that will allow you to prove that the *activity varies* inversely with the square of the distance from the source. In doing this:

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

Y-axis: Activity in Becquerel (Bq), X-axis: $^1/d^2$ *in* (m^{-2}) (1 mark)

b If this relationship was confirmed, what shape would the graph take?

The graph would be linear (a straight line).



(1 mark)

 ISBN 978 1 4860 2222 9

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.

Distance (*d*) from the source (m)	**Activity (Bq)**	**$1/d^2$ (m^{-2})**
0.10	1900	100.0
0.15	844	44.0
0.20	475	25.0
0.25	304	16.0
0.30	211	11.0
0.35	155	8.2
0.40	119	6.3
0.45	94	4.9
0.50	76	4.0

1 mark for correct labelling of axes and labelling of graph.

1 mark for accurate plotting of data (should be linear).

1 mark for appropriate size of graph and scales used. (3 marks)