

DATA ANALYSIS (Questions)

Total Marks 27

The Decay of Thorium-234

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_0 = the original number of atoms of radioactive material.

Let N = the number of atoms of radioactive material present after n half-lives have passed.

$$\text{Therefore, } N = \frac{N_0}{2^n} = N_0 \left(\frac{1}{2} \right)^n \quad N = \frac{N_0}{2^n} = N_0 \left(\frac{1}{2} \right)^n$$

Questions

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

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

- 2 Produce a fully labelled graph of N versus t . (4)
- 3 What is the name for a curve of the shape shown in your graph of N versus t ? (1)
- 4 Produce a fully labelled graph of activity versus time. (3)
- 5 What is the half-life of thorium-234? (1)

- 6 How many atoms of thorium-234 decayed during the:
- a first 24 days? (1)
 - b first 96 days? (1)
 - c last 96 days? (1)
 - d last 24 days? (1)

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 Plot a graph of activity versus distance from the source. (3)
- 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 $\text{activity} \propto \frac{1}{d^2}$? (2)
 - b If this relationship was confirmed, what shape would the graph take? (1)
 - 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)
- 9 From a quick internet search, find out if there are any health concerns related to thorium and why some people have taken great interest in using thorium. (2)

DATA ANALYSIS (Solutions)

Total Marks 27

1

t (days)	n (no. of half-lives passed)	No. of atoms of radioactive isotope	Activity (Bq) 10 cm from sample
0	0	8.0×10^{10}	1900
24	1	4.0×10^{10}	950
48	2	2.0×10^{10}	475
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

3

2	<p style="text-align: center;">Number of atoms vs time</p> <p>1 mark correct labelling of axes and labelling of graph. 2 marks for accurate plotting of data (exponential decay). 1 mark appropriate size of graph and scales used.</p>	4
3	This is an exponential decay curve.	1

4	<p style="text-align: center;">Activity vs time</p>
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	<p>Distance (d) from the source (m)</p> <p>Activity (Bq)</p> <p>$1/d^2$ (m⁻²)</p> <p>0.10 1900 100.00</p> <p>0.15 844 44.44</p> <p>0.20 475 25.00</p> <p>0.25 304 16.00</p> <p>0.30 211 11.11</p> <p>0.35 155 8.16</p> <p>0.40 119 6.25</p> <p>0.45 94 4.94</p> <p>0.50 76 4.00</p> <p>1 mark for correct labelling of axes and labelling of graph.</p> <p>1 mark for accurate plotting of data (should be linear).</p> <p>1 mark for appropriate size of graph and scales used.</p>	
9	<p>Thorium is an alpha emitter, so it has few health concerns unless dust is breathed in or contaminated food is ingested. Mantles for gas lanterns should not be a concern.</p> <p>The real interest in thorium is as a nuclear fuel because it is much more abundant than uranium, produces less waste, and is easier to handle and design for.</p>	<p>1</p> <p>1</p>