Do not write outside the box

0 6 Lanthanum-140 is a radioactive isotope.

0 6 . 1 A nucleus of lanthanum-140 emits gamma radiation.

What happens to the mass number and the charge of the nucleus when gamma radiation is emitted?

[1 mark]

Tick (✓) **one** box.

Mass number	**Charge**	
Decreases	Decreases	☐
Decreases	Stays the same	☐
Stays the same	Decreases	☐
Stays the same	Stays the same	☐

0 6 . 2 Why is it difficult to detect gamma radiation?

[1 mark]

____

____

Question 6 continues on the next page

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0 6 . 3 Activity is the rate at which a radioactive source decays.

A teacher measured the count-rate from a sample of lanthanum-140 using a Geiger-Muller (G-M) tube.

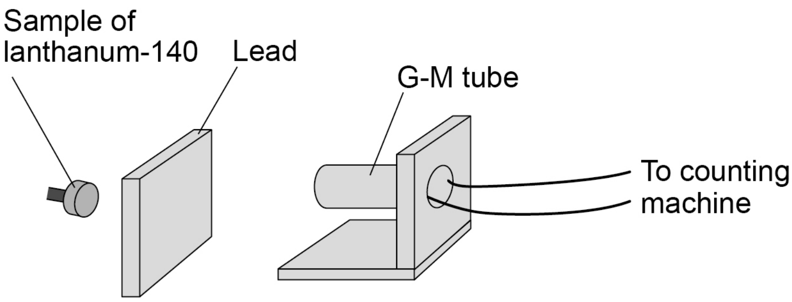
Explain why the count rate was less than the activity of the sample of lanthanum-140

[2 marks]

The teacher investigated how the thickness of lead affected the amount of gamma radiation that could pass through it.

Figure 6 shows the apparatus.

Figure 6



0 6 . 4 Explain why the teacher stood as far away from the apparatus as possible.

[2 marks]

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Table 1 shows the results.

Table 1

Thickness of lead in cm	**Count rate in counts per second**
0.5	110
1.0	60
1.5	33
2.0	18
2.5	10

0 6 . 5 The teacher concluded that the count rate was **not** inversely proportional to the thickness of lead.

Explain why the teacher was correct.

Use the data in **Table 1**.

[3 marks]

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0 6 . 6 Lanthanum-140 can also emit beta radiation and change into cerium.

Complete the equation showing the decay of lanthanum (La) 140 into cerium (Ce).

[2 marks]

$$^{140}_{57}La \longrightarrow \, ^{\_\_}_{\_\_}e + \, ^{\_\_}_{\_\_}Ce$$

Turn over ►

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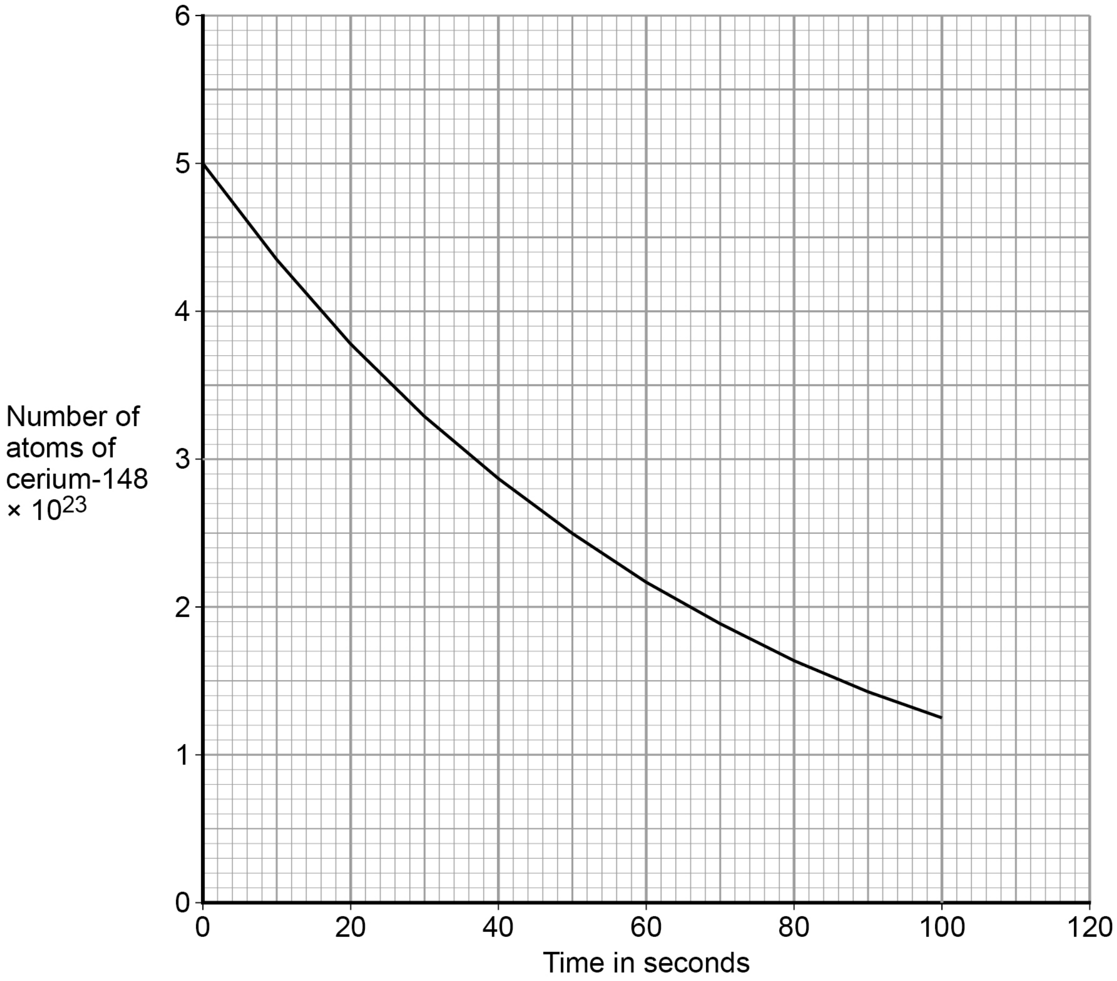
There are other isotopes of cerium which are radioactive.

Different isotopes of cerium have different half-lives.

The half-life of an isotope can be found by studying how the number of atoms changes over time.

Figure 7 shows how the number of atoms of cerium-148 in a 120 g sample changes over time.

Figure 7



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0 6 . 7 Determine the ratio of the number of cerium atoms in the sample when it was 100 seconds old compared with when the sample was 350 seconds old.

Use data from **Figure 7**.

[4 marks]

Ratio = ____________________

0 6 . 8 Determine the activity of the sample of cerium when the sample was 20 seconds old.

Use **Figure 7**.

[3 marks]

Activity = ____________________ Bq

18

END OF QUESTIONS

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
06.1	mass number stays the same, charge stays the same		1	AO1.1 6.4.2.2	A
06.2	gamma radiation is only weakly ionising **or** most gamma radiation will pass through any detector	allow gamma radiation is very penetrating	1	AO1.1 6.4.2.1	E
06.3	any two from • the radiation spreads out in all directions • only some of the radiation goes into the G-M tube • only some of the radiation passing into the GM tube is detected	allow **2** marks for only some of the radiation passing into the GM tube is detected because gamma is weakly ionising	2	AO1.1 6.4.2.4	E
06.4	to reduce the amount of radiation received because radiation increases the risk of cancer or (genetic) mutation	allow to reduce irradiation (of the teacher) allow causes cancer or (genetic) mutation ignore references to contamination	1 1	AO1.1 6.4.2.1 WS 1.4	E

06.5	a calculation of the product of thickness and count rate a second calculation of the product of thickness and count rate a comparison of the calculated values and a recognition that they are different **OR** A calculation of half the count rate (1) A comparison with the count rate for double that thickness (1) A recognition that the values are different (1)	examples of calculations 0.5 × 110 = 55 1.0 × 60 = 60 1.5 × 33 = 50 2.0 × 18 = 36 2.5 × 10 = 25 e.g. $\frac{110}{2} = 55$ the first two marks may be scored for a count rate divided by 3, 4 or 5 compared with the corresponding count rate for 3, 4 or 5 times the thickness e.g. 55 ≠ 60	1 1 1	AO3.1b 6.4.2.1	E
06.6	$^{140}_{57}\text{La} \longrightarrow {}^{0}_{-1}\text{e} + {}^{140}_{58}\text{Ce}$	allow **1** mark for correct numbers on electron allow **1** mark for correct numbers on Ce	2	AO1.1 AO1 in isolation AO1.2 6.4.2.2	E

06.7		an answer of $\frac{1}{32}$ or equivalent scores **4** marks		AO3.1a 6.4.2.3	E
	half-life = 50 seconds	this may be indicated on Figure 7	1		
	250 seconds difference in age = 5 half lives	allow 100 seconds = 2 half lives **and** 350 seconds = 7 half lives	1		
	ratio = $\left(\frac{1}{2}\right)^5$ **or** ratio = $\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}$	allow this mark if they have halved 1.25(× 10^{23}) five times to get 0.0390625(× 10^{23}) for example 1.25(× 10^{23}) → 0.625(× 10^{23})→ 0.3125(× 10^{23})→ 0.15625(× 10^{23}) → 0.078125(× 10^{23})→0.0390625(× 10^{23})	1		
	ratio = $\frac{1}{32}$ **or** ratio = 1:32	allow ratio = 0.031 allow 32:1 **or** 32	1		
06.8	tangent drawn on graph	do not allow a line drawn that crosses the graph line	1	AO2.2 6.4.2.1	E
	use of gradient = $\frac{(\Delta \text{ no. of atoms})}{\Delta \text{ time}}$	values must be taken from their tangent drawn at 20 seconds	1		
	gradient = 5.3 (× 10^{21}) (Bq)	allow gradient = 0.053 (× 10^{23}) (Bq) allow a range between 4.7 (× 10^{21}) (Bq) and 5.9 (× 10^{21}) (Bq)	1		
Total			**18**		