AQA GCSE Physics | 8463

SPECIFICATION POINT 4.4.2.2

Nuclear equations

Past-paper questions

Tier	**Foundation**
Question groups	**9**
Available paper years	**2006–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.4.2.2 Nuclear equations

Question 01

June 2006 | 3451 | Original Q4 | Legacy

4 (a) The diagrams, **A**, **B** and **C**, represent three different nuclei.

Diagram A



2 protons ⊕
4 neutrons ○

Diagram B



3 protons ⊕
3 neutrons ○

Diagram C



2 protons ⊕
2 neutrons ○

(i) Which **two** nuclei are isotopes of the same element?

..... and .....

(1 mark)

(ii) Which **two** nuclei have the same mass number?

..... and .....

(1 mark)

(iii) Give a reason for your choice of answer to part (a)(ii).

.....

.....

(1 mark)

4.4.2.2 Nuclear equations

Question 01 · continued

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(b) The tables below give examples of some stable nuclei and some unstable nuclei.

Stable nuclei
boron-11
carbon-12
oxygen-16
lead-207

Unstable nuclei
boron-12
carbon-14
oxygen-15
lead-209

(i) Write down, from the tables, the names of **two** radioactive nuclei.

..... and .....

(1 mark)

(ii) Write down, from the tables, the names of **two** non-radioactive nuclei.

..... and .....

(1 mark)

(c) Complete the following sentence by crossing out the **two** words in the box that are wrong.

The lungs of a person who has breathed in a radioactive gas will be most damaged if the gas gives out

alpha
beta
gamma

radiation.

(1 mark)

6

4.4.2.2 Nuclear equations

Question 02

June 2006 | 3462 | Original Q4 | Legacy

4 (a) The diagrams, **A**, **B** and **C**, represent three different nuclei.

Diagram A



2 protons ⊕
4 neutrons ○

Diagram B



3 protons ⊕
3 neutrons ○

Diagram C



2 protons ⊕
2 neutrons ○

(i) Which **two** nuclei are isotopes of the same element?

..... and .....

(1 mark)

(ii) Which **two** nuclei have the same mass number?

..... and .....

(1 mark)

(iii) Give a reason for your choice of answer to part (a)(ii).

.....

.....

(1 mark)

4.4.2.2 Nuclear equations

Question 02 · continued

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(b) The tables below give examples of some stable nuclei and some unstable nuclei.

Stable nuclei
boron-11
carbon-12
oxygen-16
lead-207

Unstable nuclei
boron-12
carbon-14
oxygen-15
lead-209

(i) Write down, from the tables, the names of **two** radioactive nuclei.

..... and .....

(1 mark)

(ii) Write down, from the tables, the names of **two** non-radioactive nuclei.

..... and .....

(1 mark)

(c) Complete the following sentence by crossing out the **two** words in the box that are wrong.

The lungs of a person who has breathed in a radioactive gas will be most damaged if the gas gives out

alpha
beta
gamma

radiation.

(1 mark)

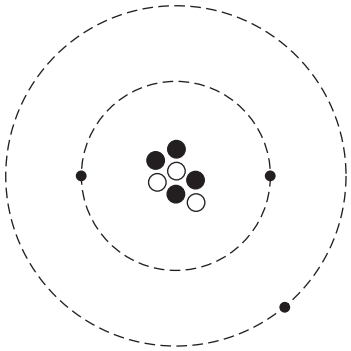
6

4.4.2.2 Nuclear equations

Question 03

January 2010 | PHY2F | Original Q4 | Legacy

4 The diagram represents an atom of lithium.



4 (a) (i) Complete the following table of information for an atom of lithium.

Number of protons	
Number of electrons	
Number of neutrons	

(2 marks)

4 (a) (ii) What is the mass number of a lithium atom?

Draw a ring around your answer.

3	**4**	**7**	**10**

Give a reason for your answer.

.....

.....

(2 marks)

4 (b) Complete the following sentence by drawing a ring around the correct line in the box.

An atom that has lost an electron is called

an ion
an isotope
a positive atom

.

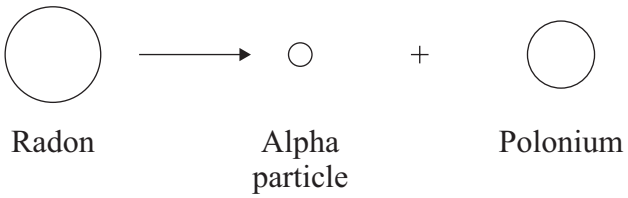
(1 mark)

4.4.2.2 Nuclear equations

Question 03 · continued

for mark

4 (c) When an alpha particle is emitted from the nucleus of a radon atom, the radon changes into polonium.



Not to scale

An alpha particle consists of 2 protons and 2 neutrons.

4 (c) (i) Complete the following sentence by drawing a ring around the correct line in the box.

The mass of a polonium atom is

greater than
the same as
smaller than

the mass of a radon atom.

(1 mark)

4 (c) (ii) Give a reason for your answer to part (c)(i).

.....

.....

(1 mark)

7

4.4.2.2 Nuclear equations

Question 04

June 2015 | PH2FP | Original Q6 | Legacy

6 (a) Radioactive sources that emit alpha, beta or gamma radiation can be dangerous.

What is a possible risk to health caused by using a radioactive source?

[1 mark]

.....

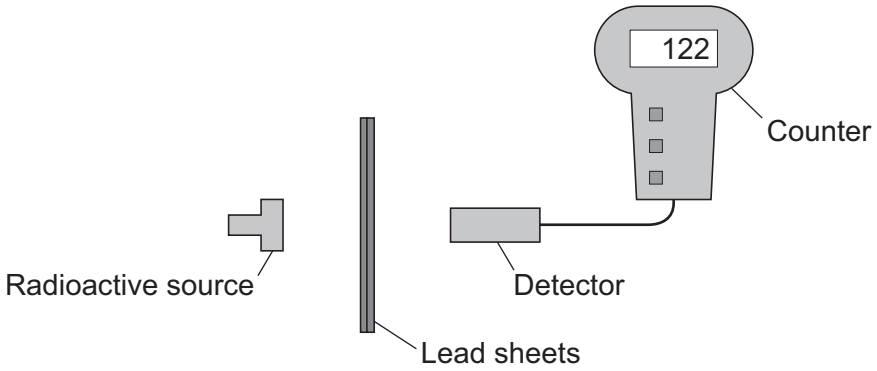
.....

6 (b) In an experiment, a teacher put a 2 mm thick lead sheet in front of a radioactive source. She used a detector and counter to measure the radiation passing through the lead sheet in one minute.

She then put different numbers of lead sheets, each 2 mm thick, in front of the radioactive source and measured the radiation passing through in one minute.

The apparatus the teacher used is shown in **Figure 7**.

Figure 7



6 (b) (i) When using a radioactive source in an experiment, how could the teacher reduce the risk to her health?

Suggest **one** way.

[1 mark]

.....

.....

Question 6 continues on the next page

4.4.2.2 Nuclear equations

Question 04 · continued

6 (b) (ii) The number recorded on the counter is actually higher than the amount of radiation detected from the source.

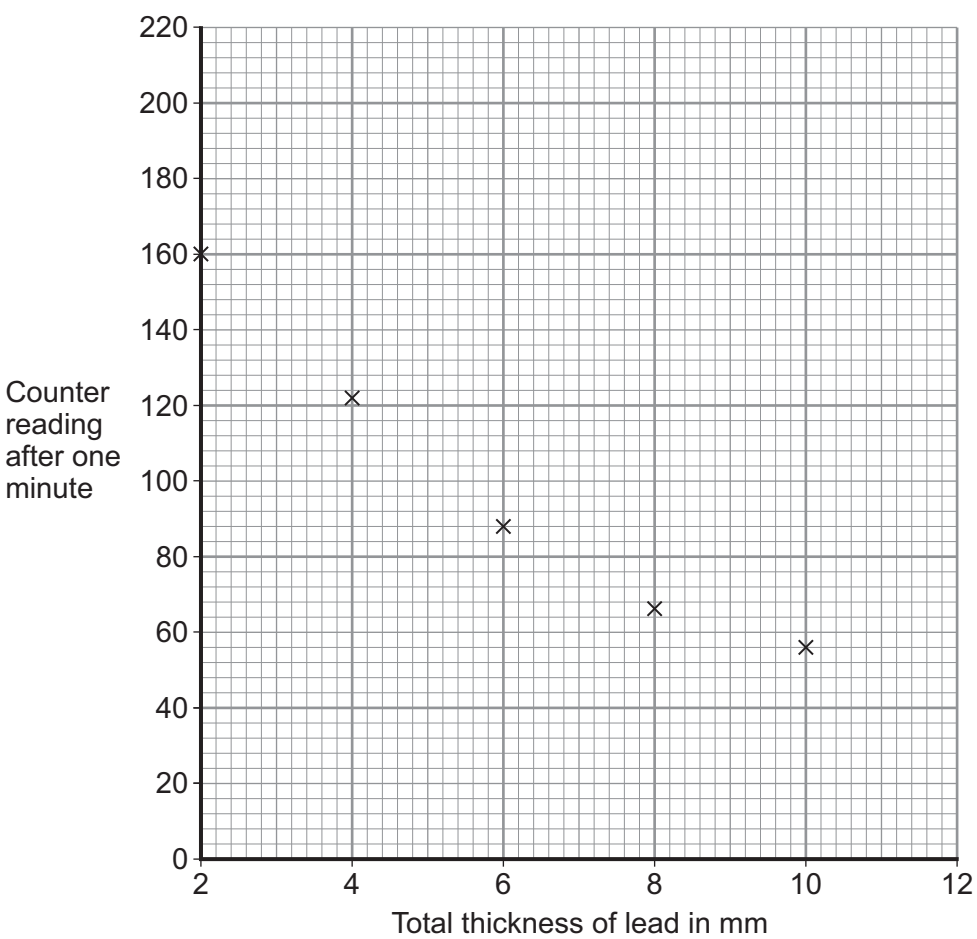
Complete the following word equation.

[1 mark]

The number recorded on the counter	=	The amount of radiation detected from the source	+	..... radiation

6 (c) The readings taken by the teacher are plotted in **Figure 8**.

Figure 8



6 (c) (i) Draw a line of best fit to complete **Figure 8**.

[1 mark]

4.4.2.2 Nuclear equations

Question 04 · continued

6 (c) (ii) How does the amount of radiation **absorbed** by the lead change as the total thickness of the lead is increased?

[1 mark]

.....

.....

6 (c) (iii) Use **Figure 8** to estimate the reading on the counter when the total thickness of the lead is increased to 12 mm.

[1 mark]

Estimated counter reading = ...

6 (d) What type of radiation was emitted from the radioactive source?

[2 marks]

Draw a ring around the correct answer.

alpha **beta** **gamma**

Give a reason for your answer.

.....

.....

8

4.4.2.2 Nuclear equations

Question 05

June 2019 | 8463/1F | Original Q2

0 2 Polonium-210 ($^{210}_{84}Po$) is a radioactive isotope that decays by emitting alpha radiation.

0 2 . 1 Which is the correct decay equation for polonium-210?

[1 mark]

Tick (✓) **one** box.

$^{210}_{84}Po \rightarrow {}^{214}_{86}X + {}^{4}_{2}He$ ☐

$^{210}_{84}Po \rightarrow {}^{206}_{86}X + {}^{4}_{2}He$ ☐

$^{210}_{84}Po \rightarrow {}^{206}_{82}X + {}^{4}_{2}He$ ☐

0 2 . 2 Why is alpha radiation dangerous inside the human body?

[1 mark]

Tick (✓) **one** box.

Alpha radiation is electromagnetic radiation. ☐

Alpha radiation is highly ionising. ☐

Alpha radiation is very penetrating. ☐

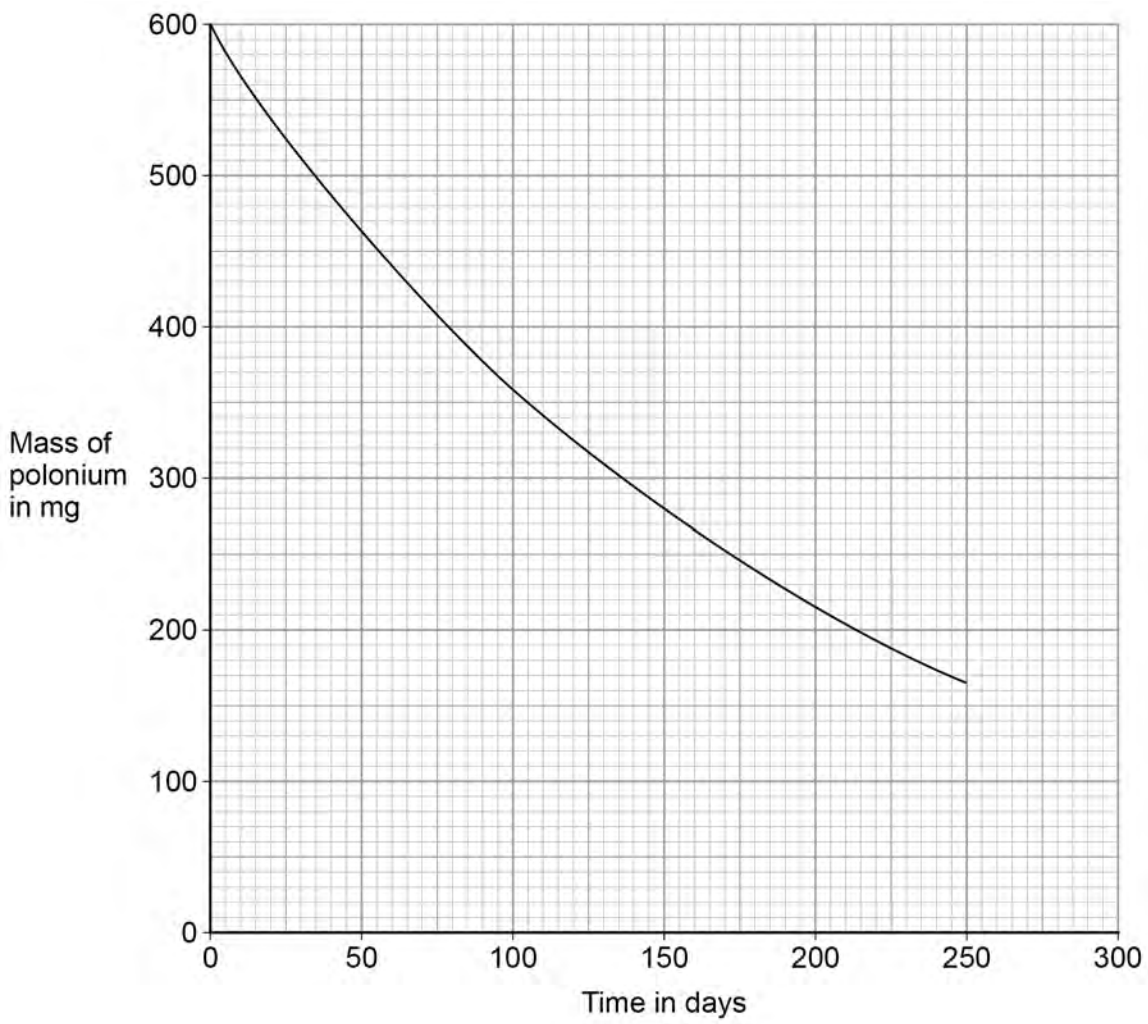
Question 2 continues on the next page

4.4.2.2 Nuclear equations

Question 05 · continued

Figure 3 shows how the mass of a sample of polonium-210 changes with time.

Figure 3



0 2 . 3 Determine the change in mass of the sample of polonium-210 between 50 and 150 days.

[2 marks]

Change in mass = _____ mg

4.4.2.2 Nuclear equations

Question 05 · continued

0 2 . 4 Estimate the mass of polonium-210 remaining after 300 days.

[1 mark]

Mass = _____ mg

0 2 . 5 Nuclear radiation can cause ionisation.

Complete the sentences.

Choose answers from the box.

[2 marks]

a negative	**an electron**	**a neutron**	**a positive**	**a proton**	**a zero**

An atom becomes an ion when it loses _____.

The resulting ion has _____ charge.

4.4.2.2 Nuclear equations

Question 06

November 2020 | 8463/1F | Original Q5

0 5 Radioactive waste from nuclear power stations is a man-made source of background radiation.

0 5 . 1 Which of the following is also a man-made source of background radiation?

[1 mark]

Tick (✓) **one** box.

- cosmic rays ☐
- radiotherapy ☐
- rocks ☐
- stars ☐

0 5 . 2 Nuclear power stations use the process of nuclear fission.

Complete the sentences to describe the process of nuclear fission.

Choose answers from the box.

[3 marks]

a neutron	**a proton**		**an electron**
cosmic rays	**energy**	**gamma rays**	**x-rays**

An unstable nucleus absorbs _____ and splits into two parts.

Two or three neutrons are released, as well as _____

and _____ .

4.4.2.2 Nuclear equations

Question 06 · continued

0 5 . 3 Plutonium-239 is one type of radioactive waste from nuclear power stations.

The following nuclear equation represents the decay of plutonium-239 (Pu-239).

$$^{239}_{94}Pu \rightarrow {}^{235}_{92}U + {}^{4}_{2}He$$

How does the nuclear equation show that alpha radiation is emitted when plutonium-239 decays?

[1 mark]

Tick (✓) **one** box.

An alpha particle contains 92 protons. ☐

An alpha particle has a mass number of 235. ☐

An alpha particle is the same as a helium nucleus. ☐

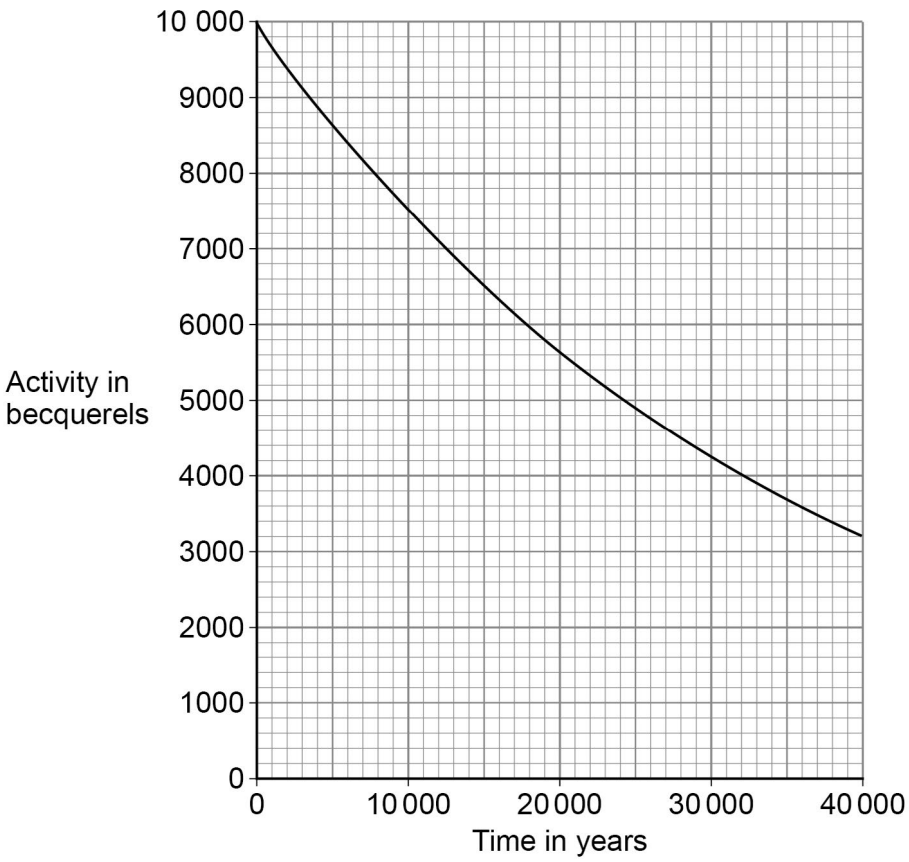
Question 5 continues on the next page

4.4.2.2 Nuclear equations

Question 06 · continued

Figure 8 shows how the activity of a sample of plutonium-239 varies with time.

Figure 8



0 5 . 4 How much time will it take for the activity of the sample of plutonium-239 to fall to half of its initial activity?

[1 mark]

Time = _____ years

0 5 . 5 What is the half-life of plutonium-239?

[1 mark]

Half-life = _____ years

4.4.2.2 Nuclear equations

Question 06 · continued

0 5 . 6 The radioactive waste from a nuclear power station is buried underground.

People are warned to stay away from places where radioactive waste is buried.

Suggest **one** risk of going near the place where radioactive waste is buried.

[1 mark]

8

Turn over for the next question

4.4.2.2 Nuclear equations

Question 07

November 2021 | 8463/1F | Original Q5

0 5 Atoms of different elements have different properties.

0 5 . 1 Which of the following is the same for all atoms of the same element?

[1 mark]

Tick (✓) **one** box.

Atomic number ☐

Mass number ☐

Neutron number ☐

0 5 . 2 Which of the following is different for isotopes of the same element?

[1 mark]

Tick (✓) **one** box.

Number of electrons ☐

Number of neutrons ☐

Number of protons ☐

Question 5 continues on the next page

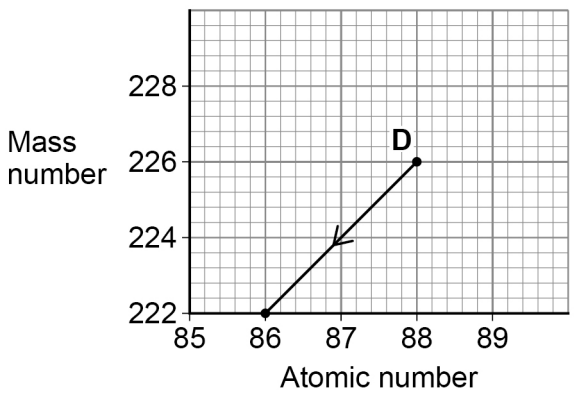
4.4.2.2 Nuclear equations

0 5 . 3 A nucleus emits radiation.

Figure 7 shows how the mass number and the atomic number change.

The nucleus is labelled **D**.

Figure 7



Which type of radiation is emitted when nucleus **D** decays?

[1 mark]

Tick (✓) **one** box.

Alpha ☐

Beta ☐

Neutron ☐

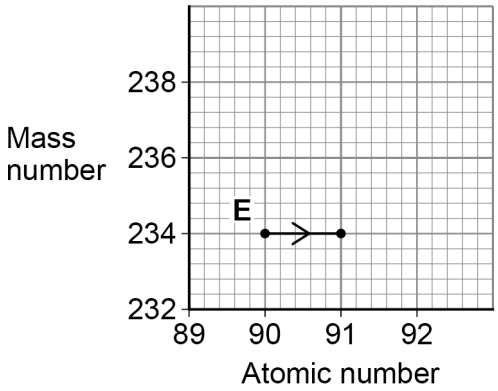
4.4.2.2 Nuclear equations

Question 07 · continued

0 5 . 4 Nucleus **E** also emits radiation.

Figure 8 shows how the mass number and the atomic number change for nucleus **E**.

Figure 8



Which type of radiation is emitted when nucleus **E** decays?

[1 mark]

Tick (✓) **one** box.

Alpha ☐

Beta ☐

Neutron ☐

Question 5 continues on the next page

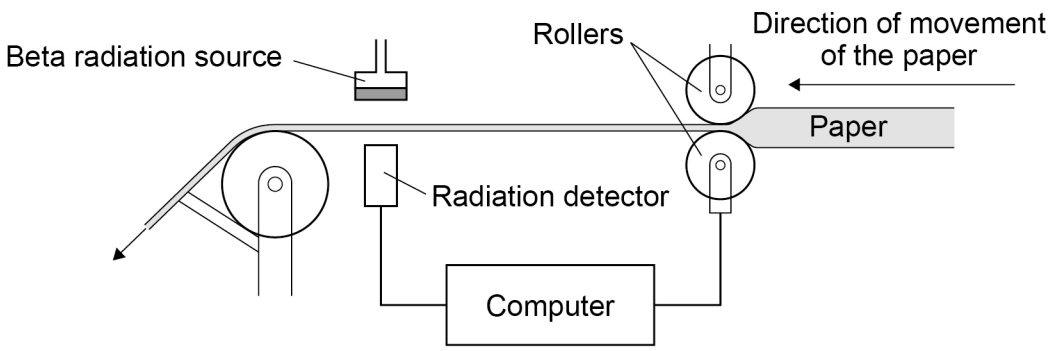
4.4.2.2 Nuclear equations

Question 07 · continued

Beta radiation can be used to monitor the thickness of paper during production.

Figure 9 shows how the radiation is used.

Figure 9



The computer uses information from the radiation detector to change the size of the gap between the rollers.

0 5 . 5 Complete the sentences.

Choose answers from the box.

Each answer can be used once, more than once or not at all.

decrease	**stay the same**	**increase**

The thickness of the paper between the beta source and the detector increases.

[2 marks]

The reading on the detector will _____.

This is because the amount of radiation absorbed by the paper

will _____.

4.4.2.2 Nuclear equations

Question 07 · continued

0 5 . 6 All radioactive elements have a half-life.

What is meant by 'half-life'?

[1 mark]

Tick (✓) **one** box.

- The time it takes for all the nuclei in a radioactive sample to split in half. ☐
- The time it takes for the count rate of a radioactive sample to halve. ☐
- The time it takes for the radiation to travel half of its range in air. ☐

0 5 . 7 Why should the radiation source used in **Figure 9** have a long half-life?

[1 mark]

Tick (✓) **one** box.

- So the activity of the source is approximately constant. ☐
- So the amount of radiation decreases quickly. ☐
- So the radiation has a long range in air. ☐

8

4.4.2.2 Nuclear equations

Question 08

June 2022 | 8463/1F | Original Q4

0 4 Radioactive isotopes emit different types of nuclear radiation.

0 4 . 1 What does an alpha particle consist of?

[1 mark]

Tick (✓) **one** box.

- 2 protons and 2 electrons ☐
- 2 protons and 2 neutrons ☐
- 4 protons ☐
- 4 neutrons ☐

0 4 . 2 What is a beta particle?

[1 mark]

Tick (✓) **one** box.

- An electron ☐
- A neutron ☐
- Electromagnetic radiation ☐

0 4 . 3 A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

What is the correct equation for this decay?

[1 mark]

Tick (✓) **one** box.

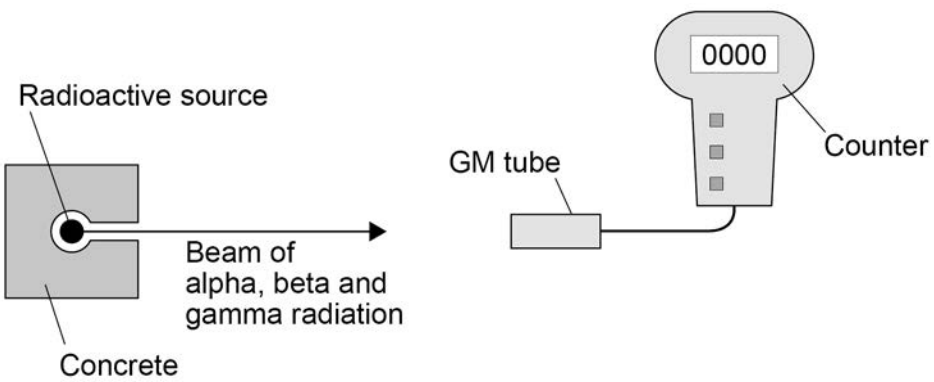
- $^{85}_{36}Kr + {}^{0}_{-1}e \longrightarrow {}^{85}_{37}Rb$ ☐
- $^{85}_{36}Kr \longrightarrow {}^{85}_{37}Rb + {}^{0}_{-1}e$ ☐
- $^{85}_{37}Rb \longrightarrow {}^{85}_{36}Kr + {}^{0}_{-1}e$ ☐

Question 08 · continued

0 4 . 4 **Figure 5** shows an experiment to demonstrate how alpha, beta and gamma radiation penetrate different materials.

The experiment takes place in a vacuum.

Figure 5



Three different materials are used:

- a sheet of paper
- a 0.5 cm thick sheet of aluminium
- a 10 cm block of lead.

Each material is placed one at a time between the radioactive source and the GM tube.

The GM tube and counter show whether the material has stopped the radiation.

Complete **Table 1** to show how alpha, beta and gamma radiation penetrate the materials in **Figure 5**.

Use the words **Yes** and **No**.

Part of **Table 1** has been completed for you.

[3 marks]

Table 1

Type of radiation	Most radiation is stopped by:		
	the sheet of paper	the sheet of aluminium	the block of lead
Alpha			Yes
Beta	No		
Gamma		No	

4.4.2.2 Nuclear equations

Question 08 · continued

0 4 . 5 Alpha, beta and gamma radiation have different ionising powers.

Draw **one** line from each radiation type to the correct ionising power.

[3 marks]

Radiation type	Ionising power
Alpha	Zero
Beta	Low
Gamma	Medium
	High

0 4 . 6 Some sources of background radiation are natural and other sources are man-made.

Which of the following is a man-made source of background radiation?

[1 mark]

Tick (✓) **one** box.

Cosmic rays ☐

Nuclear accidents ☐

Rocks ☐

0 4 . 7 The average background radiation dose per year in the UK is 2.0 millisieverts.

A dental X-ray gives a patient a radiation dose of 0.005 millisieverts.

Calculate how many dental X-rays would be the same as the average background radiation dose per year.

[2 marks]

Number of dental X-rays = _____

12

4.4.2.2 Nuclear equations

Question 09

June 2025 | 8463/1F | Original Q3

0 3 Different radioactive isotopes emit different types of radiation.

0 3 . 1 One isotope of uranium (U) decays into thorium (Th) by emitting an alpha particle (He).

Which nuclear equation shows the decay of this isotope of uranium?

[1 mark]

Tick (✓) **one** box.

$^{230}_{92}U \rightarrow {}^{226}_{90}Th + {}^{4}_{2}He$ ☐

$^{226}_{90}Th \rightarrow {}^{230}_{92}U + {}^{4}_{2}He$ ☐

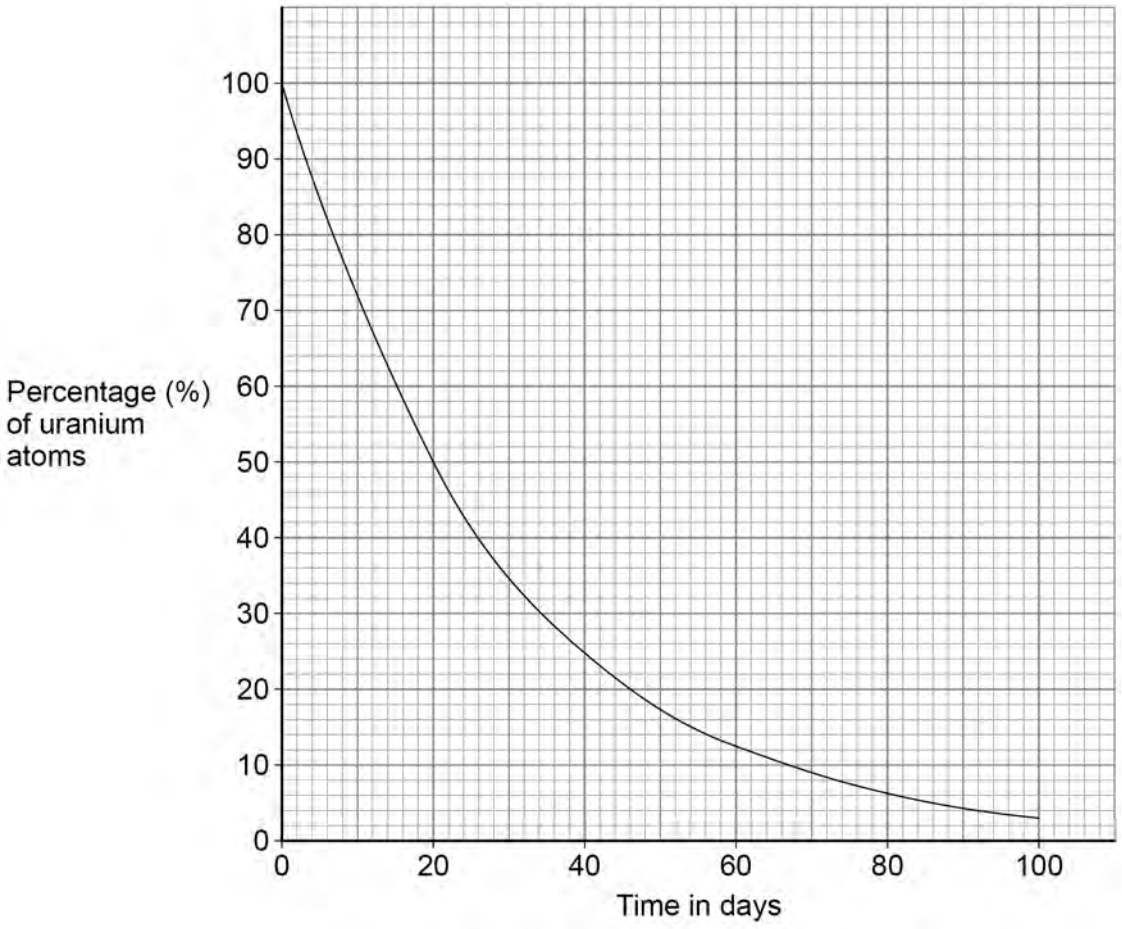
$^{230}_{92}U + {}^{226}_{90}Th \rightarrow {}^{4}_{2}He$ ☐

4.4.2.2 Nuclear equations

Question 09 · continued

Figure 4 shows how the percentage of uranium atoms in a sample of one uranium isotope varies with time.

Figure 4



0 3 . 2 What is the time taken for 50% of the atoms of this uranium isotope to decay?

Use **Figure 4**.

[1 mark]

Time taken = _____ days

0 3 . 3 What is the half-life of this uranium isotope?

[1 mark]

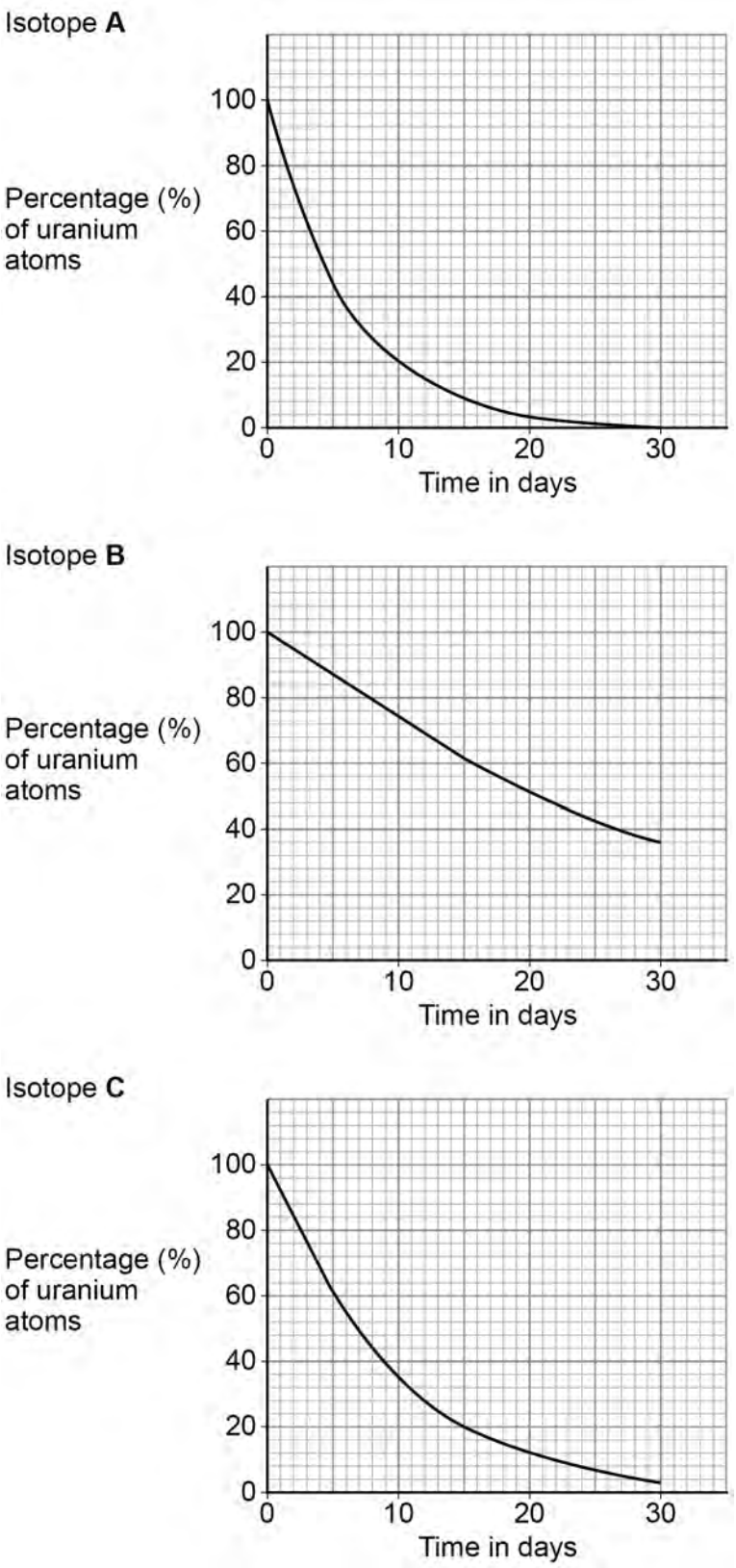
Half-life = _____ days

4.4.2.2 Nuclear equations

Question 09 · continued

0 3 . 4 **Figure 5** shows how the percentage of uranium atoms varies with time for three different isotopes of uranium, **A**, **B** and **C**.

Figure 5



4.4.2.2 Nuclear equations

Question 09 · continued

Which isotope is the most unstable?

Give a reason for your answer.

[2 marks]

Tick (✓) **one** box.

Isotope **A** ☐

Isotope **B** ☐

Isotope **C** ☐

Reason _____

_____

_____

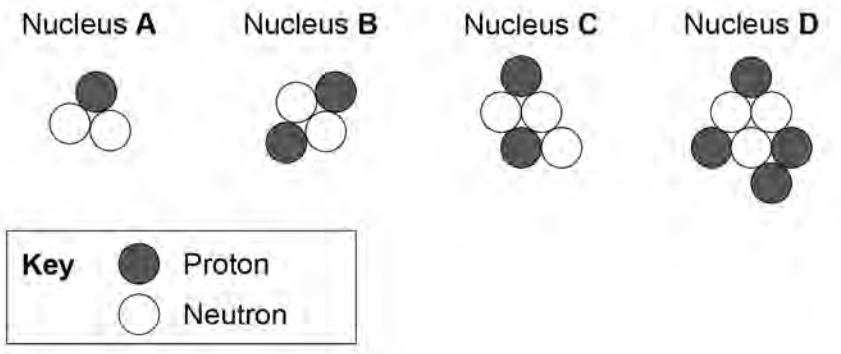
Question 3 continues on the next page

4.4.2.2 Nuclear equations

Question 09 · continued

Figure 6 shows the nuclei of four different atoms.

Figure 6



0 3 . 5 Which nucleus in **Figure 6** has the smallest **mass** number?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 3 . 6 Which nucleus in **Figure 6** has an **atomic** number of 4?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

4.4.2.2 Nuclear equations

Question 09 · continued

0 3 . 7 Which **two** nuclei in **Figure 6** are isotopes of the same element?

Give a reason for your answer.

[2 marks]

Nucleus ☐ and nucleus ☐

Reason _____

_____

Scientists have replaced old models of the atom with newer models.

The nuclear model of the atom has a nucleus at the centre.

0 3 . 8 Which model of the atom was replaced by the nuclear model?

[1 mark]

Tick (✓) **one** box.

Bohr model ☐

Plum pudding model ☐

Tiny spheres that cannot be divided ☐

0 3 . 9 What does the nuclear model state about the mass of an atom?

[1 mark]

Tick (✓) **one** box.

The mass of the atom is concentrated in the electrons. ☐

The mass of the atom is concentrated in the nucleus. ☐

The mass of the atom is spread throughout the atom. ☐

11