AQA GCSE Physics | 8463

SPECIFICATION POINT 4.4.2.2

Nuclear equations

Past-paper questions

Tier	**Higher**
Question groups	**10**
Available paper years	**2008–2025**

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 2008 | PHY2H | Original Q2 | Legacy

2 (a) The table gives information about the radioactive isotope, radon-222.

mass number	222
atomic number	86
radiation emitted	alpha particle

2 (a) (i) Complete the following sentence.

The mass number is the total number of..... and

..... inside an atom.

(2 marks)

2 (a) (ii) Radon-222 is an isotope of radon.

How many protons are there in an atom of radon-222?

..... *(1 mark)*

2 (a) (iii) When an atom of radon-222 emits an alpha particle, the radon-222 changes into an atom of polonium-218.

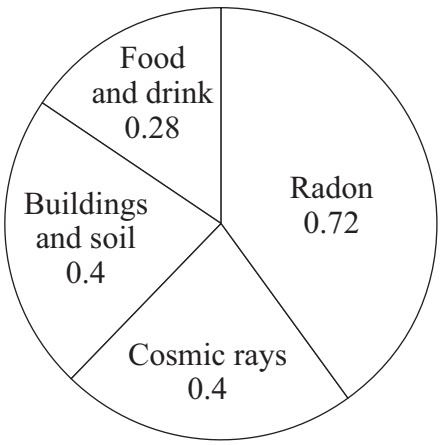
An alpha particle consists of 2 protons and 2 neutrons.

How is the structure of the nucleus of a polonium-218 atom different from the structure of the nucleus of a radon-222 atom?

.....

(1 mark)

2 (b) The pie chart shows the average radiation dose that a person in the UK receives each year from natural background radiation.
The doses are measured in millisieverts (mSv).



Question 01 · continued

for mark

2 (b) (i) Calculate the proportion of natural background radiation that comes from radon. Show clearly how you work out your answer.

.....

.....

Proportion of radon = ...

(2 marks)

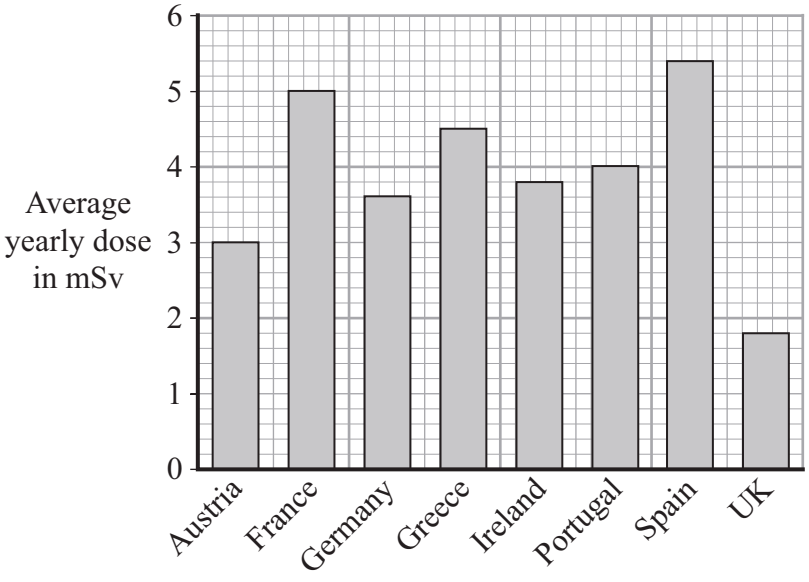
2 (b) (ii) Not all background radiation is from natural sources.

Name **one** source of background radiation that is not natural.

.....

(1 mark)

2 (c) The bar chart shows the average yearly dose from natural background radiation in different European countries.



2 (c) (i) How many times bigger is the average annual background dose in Germany compared to the UK?

.....

(1 mark)

Question 2 continues on the next page

4.4.2.2 Nuclear equations

Question 01 · continued

for mark

2 (c) (ii) The following table gives the effects of different radiation doses on the human body.

Radiation dose in mSv	Effects
10 000	Immediate illness; death within a few weeks
1 000	Radiation sickness; unlikely to cause death
50	Lowest dose with evidence of causing cancer

A family goes to Germany for a two-week holiday. Should they be concerned about the higher level of background radiation in Germany?

Draw a ring around your answer.

Yes **No**

Explain your answer.

.....

.....

.....

.....

(2 marks)

10

4.4.2.2 Nuclear equations

Question 02

January 2009 | PHY2H | Original Q6 | Legacy

6 (a) Complete the following table for an atom of uranium-238 ($^{238}_{92}U$).

mass number	238
number of protons	92
number of neutrons	

(1 mark)

6 (b) Complete the following sentence.

The name given to the number of protons in an atom is the proton number or the

..... .

(1 mark)

6 (c) An atom of uranium-238 ($^{238}_{92}U$) decays to form an atom of thorium-234 ($^{234}_{90}Th$).

6 (c) (i) What type of radiation, alpha, beta or gamma, is emitted by uranium-238?

.....

(1 mark)

6 (c) (ii) Why does an atom that decays by emitting alpha or beta radiation become an atom of a different element?

.....

.....

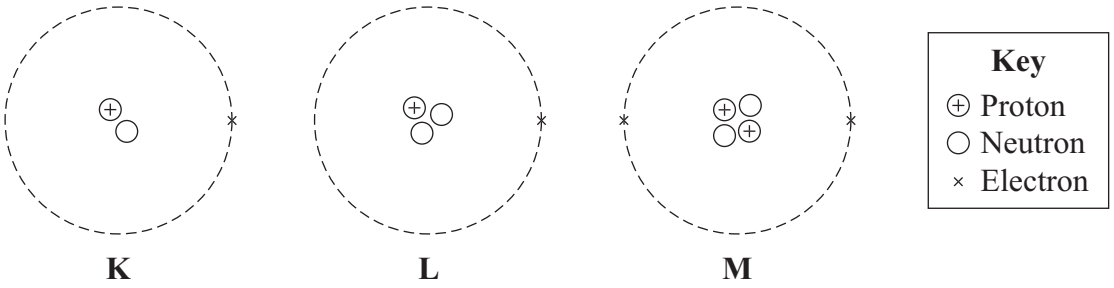
(1 mark)

4

4.4.2.2 Nuclear equations

Question 03

3 (a) The diagram represents 3 atoms, **K**, **L** and **M**.



K **L** **M**

3 (a) (i) Which **two** of the atoms are isotopes of the same element?

..... and .....

(1 mark)

3 (a) (ii) Give a reason why the **two** atoms that you chose in part (a)(i) are:

(1) atoms of the same element .....

.....

(2) different isotopes of the same element. .....

.....

.....

(2 marks)

3 (b) The table gives some information about the radioactive isotope thorium-230.

mass number	230
atomic number	90

3 (b) (i) How many electrons are there in an atom of thorium-230?

.....

(1 mark)

3 (b) (ii) How many neutrons are there in an atom of thorium-230?

.....

(1 mark)

4.4.2.2 Nuclear equations

Question 03 · continued

for mark

3 (c) When a thorium-230 nucleus decays, it emits radiation and changes into radium-226.

$$^{230}_{90}\text{Th} \longrightarrow {}^{226}_{88}\text{Ra} + \boxed{\text{Radiation}}$$

What type of radiation, alpha, beta or gamma, is emitted by thorium-230?

.....

Explain the reason for your answer.

.....

.....

.....

.....

.....

(3 marks)

8

4.4.2.2 Nuclear equations

Question 04

3 (a) Background radiation is all around us all the time.

3 (a) (i) Radon is a natural source of background radiation.

Name another natural source of background radiation.

.....

(1 mark)

3 (a) (ii) X-rays are an artificial source of background radiation.

Name another artificial source of background radiation.

.....

(1 mark)

3 (a) (iii) An atom of radon-222 decays by emitting an alpha particle.
The equation representing the decay is shown below.

$$^{222}_{86}\text{Rn} \longrightarrow {}^{218}_{84}\text{X} + \text{alpha particle}$$

How can you tell from the equation that 'X' is not an atom of radon?

.....

.....

(1 mark)

Question 3 continues on the next page

4.4.2.2 Nuclear equations

3 (b) Having an X-ray taken increases your exposure to radiation.

The table gives:

- the radiation doses received for 6 different medical X-rays;
- the number of days' of exposure to natural background radiation each dose is equivalent to.

Medical X-ray	Radiation dose received (in arbitrary units)	Equivalent number of days of exposure to natural background radiation
Chest	2	2.4
Skull	7	8.4
Pelvis	22	26.4
Hip	44	52.8
Spine	140	
CT head scan	200	240

A hospital patient has an X-ray of the spine taken.
Calculate the number of days of exposure to natural background radiation that an X-ray of the spine is equivalent to.

Show how you work out your answer.

.....

.....

.....

Equivalent number of days = ...

(2 marks)

4.4.2.2 Nuclear equations

Question 04 · continued

3 (c) Scientists have shown that X-rays increase the risk of developing cancer.
The scientists came to this conclusion by studying the medical history of people placed in one of two groups, **A** or **B**.
The group into which people were put depended on their X-ray record.

3 (c) (i) Person **J** has been placed into group **A**.
Place each of the people, **K**, **L**, **M**, **N** and **O**, into the appropriate group, **A** or **B**.

Person	J 	K 	L 	M 	N 	O 
Medical X-ray record	3 arm	None	None	2 skull	None	4 leg

Group A	Group B
J	

(1 mark)

3 (c) (ii) To be able to make a fair comparison, what is important about the number of people in each of the two groups studied by the scientists?

.....

.....

(1 mark)

3 (c) (iii) What data would the scientists have compared in order to come to the conclusion that X-rays increase the risk of developing cancer?

.....

.....

(1 mark)

Question 3 continues on the next page

4.4.2.2 Nuclear equations

Question 04 · continued

3 (c) (iv) The chance of developing cancer due to a CT head scan is about 1 in 10 000.
The chance of developing cancer naturally is about 1 in 4.

A hospital patient is advised by a doctor that she needs to have a CT head scan.
The doctor explains to the patient the risks involved.

Do you think that the patient should give her permission for the CT scan to be taken?

Draw a ring around your answer.

Yes **No**

Give a reason for your answer.

.....

.....

(1 mark)

9

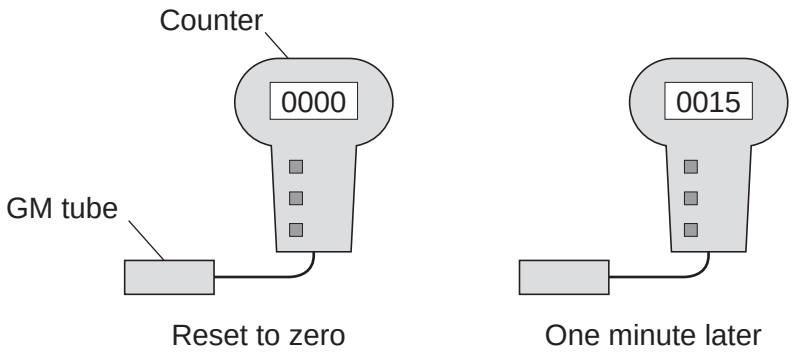
4.4.2.2 Nuclear equations

Question 05

January 2013 | PH2HP | Original Q2 | Legacy

2 (a) A teacher used a Geiger-Műller (GM) tube and counter to measure the *background radiation* in her laboratory.

The teacher reset the counter to zero, waited one minute and then took the count reading. The teacher repeated the procedure two more times.



2 (a) (i) Background radiation can be either from natural sources or from man-made sources.

Name **one man-made** source of background radiation.

.....

(1 mark)

2 (a) (ii) The three readings taken by the teacher are given in the table.

Count after one minute
15
24
18

The readings given in the table are correct.

Why are the readings different?

.....

.....

(1 mark)

4.4.2.2 Nuclear equations

Question 05 · continued

2 (b) Some scientists say they have found evidence to show that people living in areas of high natural background radiation are less likely to develop cancer than people living in similar areas with lower background radiation.

The evidence these scientists found does not definitely mean that the level of background radiation determines whether a person will develop cancer.

Suggest a reason why.

.....

.....

(1 mark)

2 (c) An atom of the isotope radon-222 emits an alpha particle and decays into an atom of polonium.

An alpha particle is the same as a helium nucleus. The symbol below represents an alpha particle.

$$^{4}_{2}\text{He}$$

2 (c) (i) How many protons and how many neutrons are there in an alpha particle?

Number of protons = ...

Number of neutrons = ...

(2 marks)

2 (c) (ii) The decay of radon-222 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.

$$^{222}_{86}\text{Rn} \longrightarrow \square\ \square + \text{Po} + \text{alpha particle}$$

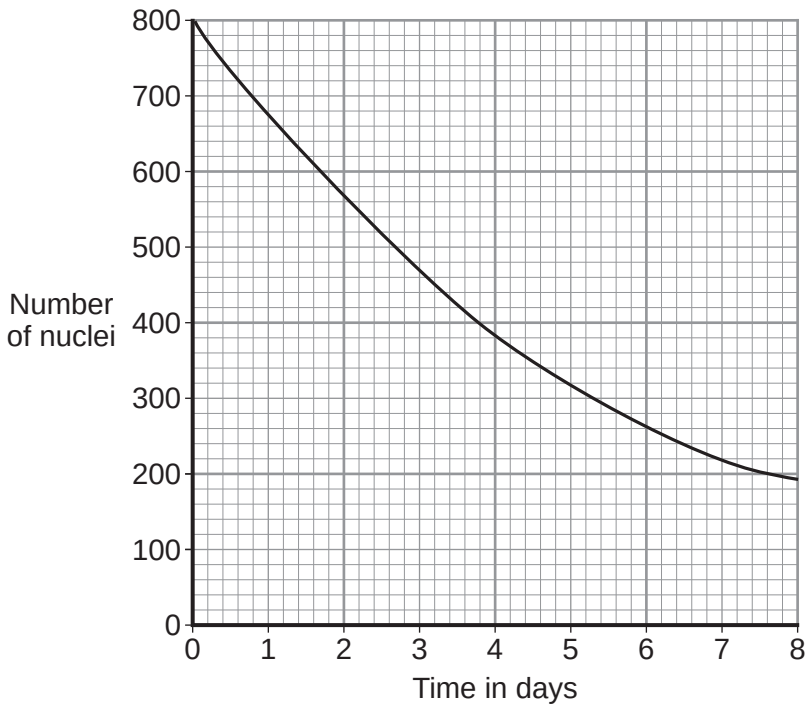
(2 marks)

Question 2 continues on the next page

4.4.2.2 Nuclear equations

Question 05 · continued

2 (d) The graph shows how, in a sample of air, the number of radon-222 nuclei changes with time.



Use the graph to find the half-life of radon-222.

Show clearly on the graph how you obtain your answer.

Half-life = ... days

(2 marks)

9

4.4.2.2 Nuclear equations

Question 06

June 2013 | PH2HP | Original Q5 | Legacy

5 In 2011 an earthquake caused severe damage to a nuclear power station in Japan. The damage led to the release of large amounts of radioactive iodine-131($^{131}_{53}I$) into the atmosphere.

5 (a) The table gives some information about an atom of iodine-131($^{131}_{53}I$).

Complete the table.

mass number	131
number of protons	53
number of neutrons	

(1 mark)

5 (b) Complete the sentence.

The number of protons in an atom is called the proton number or

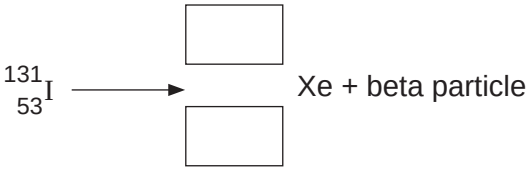
the ..... number.

(1 mark)

5 (c) An atom of iodine-131 decays into an atom of xenon (Xe) by emitting a beta particle.

5 (c) (i) The decay of iodine-131 can be represented by the equation below.

Complete the equation by writing the correct number in each of the **two** boxes.



(2 marks)

Question 5 continues on the next page

4.4.2.2 Nuclear equations

Question 06 · continued

5 (c) (ii) A sample of rainwater contaminated with iodine-131 gives a count rate of 1200 counts per second.

Calculate how many days it will take for the count rate from the sample of rainwater to fall to 75 counts per second.

Half-life of iodine-131 = 8 days

Show clearly how you work out your answer.

.....

.....

..... days
(2 marks)

5 (c) (iii) If people drink water contaminated with iodine-131, the iodine-131 builds up in the thyroid gland. This continues until the thyroid is saturated with iodine-131 and cannot absorb any more. The radiation emitted from the iodine-131 could cause cancer of the thyroid.

In Japan, people likely to be drinking water contaminated with iodine-131 were advised to take tablets containing a non-radioactive isotope of iodine.

Suggest why this advice was given.

.....

.....

.....

.....
(2 marks)

8

4.4.2.2 Nuclear equations

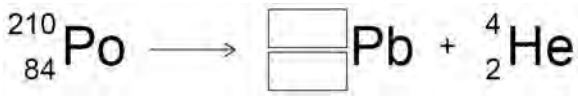
Question 07

June 2019 | 8463/1H | Original Q5

0 5 Polonium-210 $\left({}^{210}_{84}\mathrm{Po}\right)$ is a radioactive isotope that decays by emitting alpha radiation.

0 5 . 1 Complete the decay equation for polonium-210

[2 marks]



0 5 . 2 Explain why contamination of the inside of the human body by a radioactive material that emits alpha radiation is highly dangerous.

[3 marks]

4.4.2.2 Nuclear equations

Question 07 · continued

0 5 . 3 A sample of polonium-210 was left for 414 days.

After this time it had a mass of 1.45×10^{-4} g

The half-life of polonium-210 is 138 days.

Calculate the initial mass of the sample.

[3 marks]

Initial mass = _____ g

8

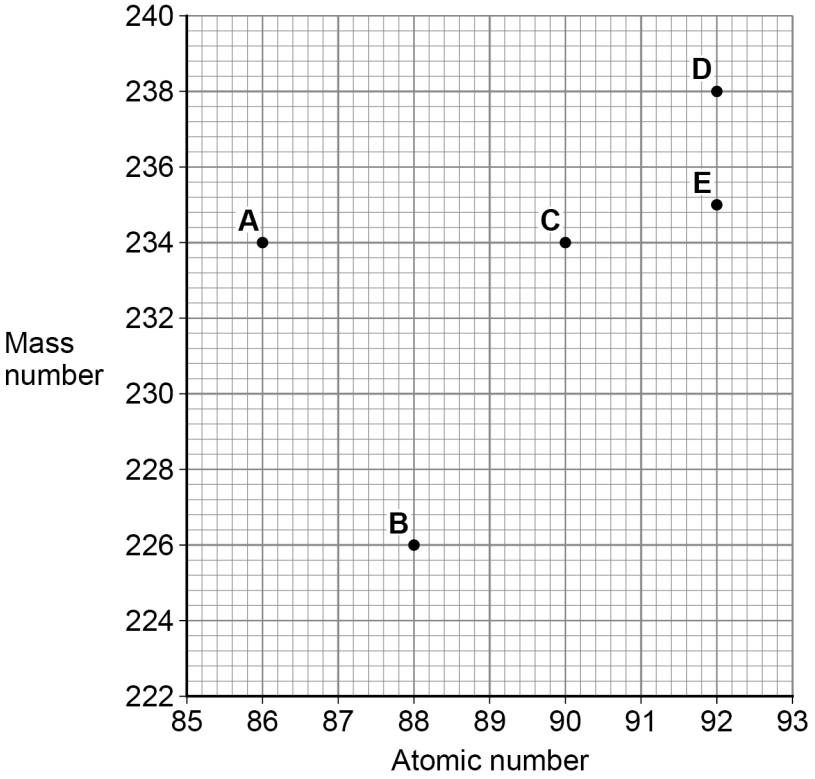
4.4.2.2 Nuclear equations

Question 08

November 2021 | 8463/1H | Original Q6

0 6 **Figure 6** shows the mass number and the atomic number for the nuclei of five different atoms.

Figure 6



0 6 . 1 How many neutrons are there in a nucleus of atom **A**?

[1 mark]

4.4.2.2 Nuclear equations

Question 08 · continued

0 6 . 2 Which **two** atoms in **Figure 6** are the same element?

[1 mark]

Tick (✓) **one** box.

A and **B** ☐

A and **C** ☐

C and **D** ☐

D and **E** ☐

Question 6 continues on the next page

4.4.2.2 Nuclear equations

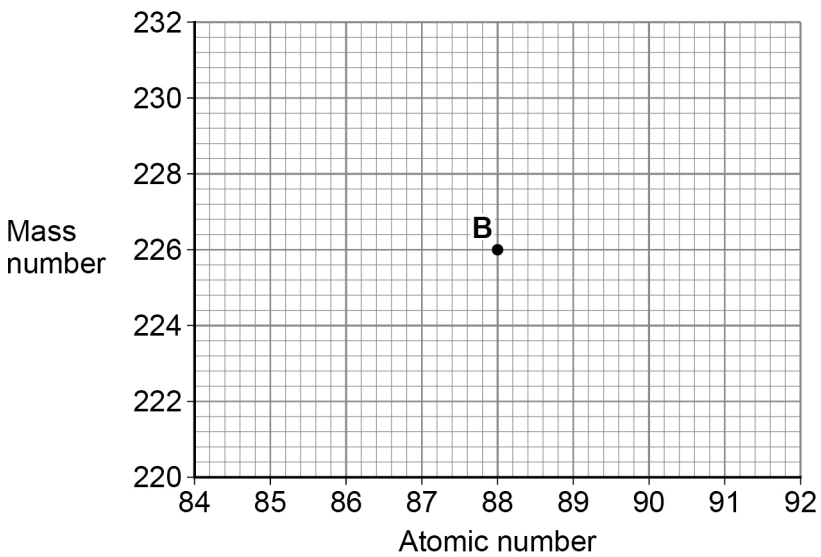
Question 08 · continued

0 6 . 3 Nucleus **B** decays by emitting an alpha particle.

Draw an arrow on **Figure 7** to represent the alpha decay.

[2 marks]

Figure 7



0 6 . 4 What is meant by the 'random nature of radioactive decay'?

[1 mark]

4.4.2.2 Nuclear equations

Question 08 · continued

0 6 . 5 A polonium (Po) nucleus decays by emitting an alpha particle and forming a lead (Pb) nucleus.

$$Po \rightarrow Pb + \alpha$$

The lead (Pb) nucleus then decays by emitting a beta particle and forms a bismuth (Bi) nucleus.

$$Pb \rightarrow Bi + \beta$$

The bismuth (Bi) nucleus then decays by emitting a beta particle and forms a polonium (Po) nucleus.

$$Bi \rightarrow Po + \beta$$

Explain how these three decays result in a nucleus of the original element, polonium.

[3 marks]

8

4.4.2.2 Nuclear equations

Question 09

June 2022 | 8463/1H | Original Q7

0 7 Alpha particles, beta particles and gamma rays are types of nuclear radiation.

0 7 . 1 What does an alpha particle consist of?

[1 mark]

0 7 . 2 A krypton (Kr) nucleus decays into a rubidium (Rb) nucleus by emitting a beta particle.

Complete the nuclear equation for this decay by writing the missing number in each box.

[2 marks]

$$\square_{36}\mathrm{Kr} \longrightarrow \square^{85}\mathrm{Rb} + {}^{0}_{-1}\mathrm{e}$$

0 7 . 3 Internal contamination of the human body means radioactive material is inside the human body.

Explain how the risk from internal contamination is different to the risk from external irradiation by a source of alpha radiation.

[5 marks]

8

4.4.2.2 Nuclear equations

Question 10

June 2025 | 8463/1H | Original Q7

0 7 Some atoms emit radiation.

0 7 . 1 Why do scientists sometimes change the model used to describe the structure of the atom?

[1 mark]

Tick (✓) **one** box.

- Existing models use ideas that are old fashioned. ☐
- New evidence is discovered that existing models cannot explain. ☐
- Scientists need to develop new models every 100 years. ☐
- The public do not understand old models so new ones are created. ☐

0 7 . 2 When radioactivity was discovered, the dangers of radiation were not known.

Some scientists were irradiated and contaminated while working with the radioactive materials.

Describe the difference between irradiation and radioactive contamination.

[2 marks]

Question 7 continues on the next page

4.4.2.2 Nuclear equations

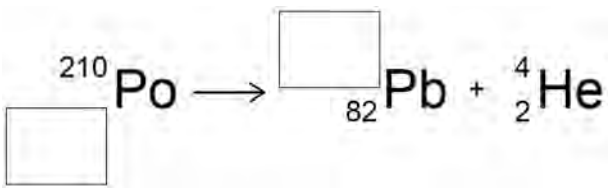
Question 10 · continued

0 7 . 3 Polonium-210 was one of the first radioactive elements to be discovered.

Polonium-210 (Po) decays into lead (Pb).

Complete the nuclear equation for polonium-210.

[2 marks]



0 7 . 4 Polonium-210 has a half-life of 138 days.

A sample of polonium contains 256 000 atoms.

Calculate the time taken for the number of polonium-210 atoms to reach 16 000.

[3 marks]

Time taken = _____ days

4.4.2.2 Nuclear equations

Question 10 · continued

0 7 . 5 A sample of polonium contains equal numbers of polonium-209 atoms and polonium-210 atoms.

Polonium-209 has a half-life of 125 **years**.

Polonium-210 has a half-life of 138 **days**.

Explain how the activity of polonium-209 compares with the activity of polonium-210 in this sample.

[2 marks]

10

Turn over for the next question