AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 6.4.1.1

The structure of an atom

Past-paper questions

Tier	**Higher**
Question groups	**9**
Available paper years	**2018–2024**

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.

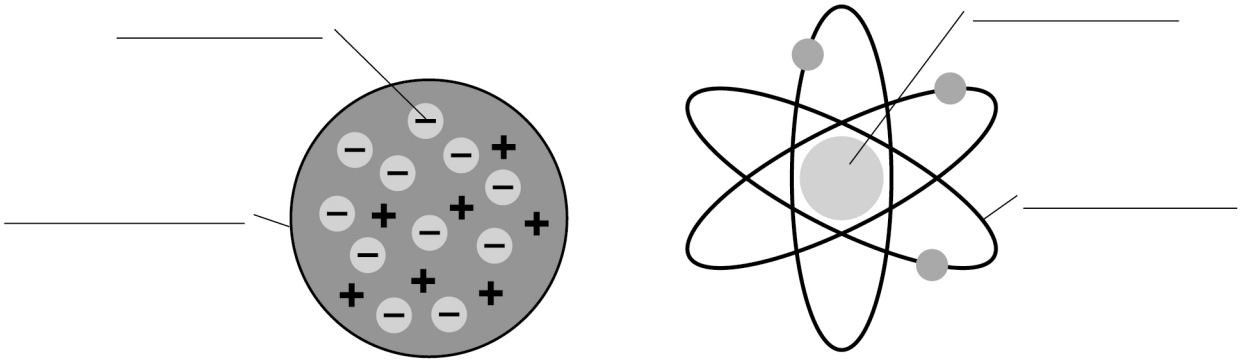
6.4.1.1 The structure of an atom

Question 01

June 2018 | 8464/P/1H | Original Q1

0 1 **Figure 1** shows two models of the atom.

Figure 1



Plum pudding model

Nuclear model

0 1 . 1 Write the labels on **Figure 1**

Choose the answers from the box.

[4 marks]

atom	**electron**	**nucleus**
neutron	**orbit**	**proton**

0 1 . 2 Explain why the total positive charge in every atom of an element is always the same.

[2 marks]

6.4.1.1 The structure of an atom

Question 01 · continued

0 1 . 3 The results from the alpha particle scattering experiment led to the nuclear model.

Alpha particles were fired at a thin film of gold at a speed of 7% of the speed of light.

Determine the speed of the alpha particles.

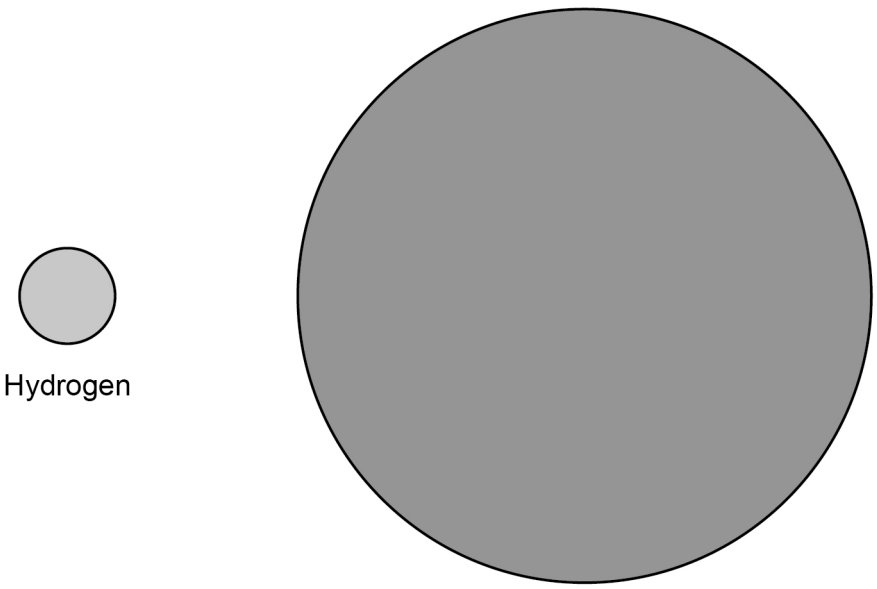
Speed of light = 300 000 000 m/s

[2 marks]

Speed = _____ m/s

0 1 . 4 **Figure 2** shows two atoms represented as solid spheres.

Figure 2



A hydrogen atom has a radius of 2.5×10^{-11} m

Determine the radius of a magnesium atom.

Use measurements from **Figure 2**

[2 marks]

Radius = _____ m

10

6.4.1.1 The structure of an atom

Question 02

June 2019 | 8464/P/1H | Original Q6

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

Question 02 · continued

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.

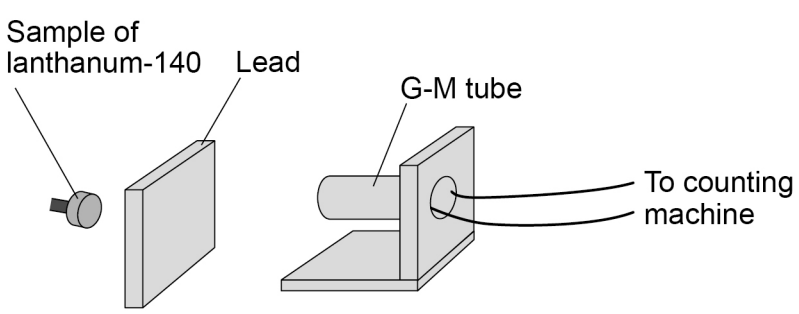
Explain why the count rate was less than the activity of the sample of lanthanum-140

[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]

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]

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]

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

Question 02 · continued

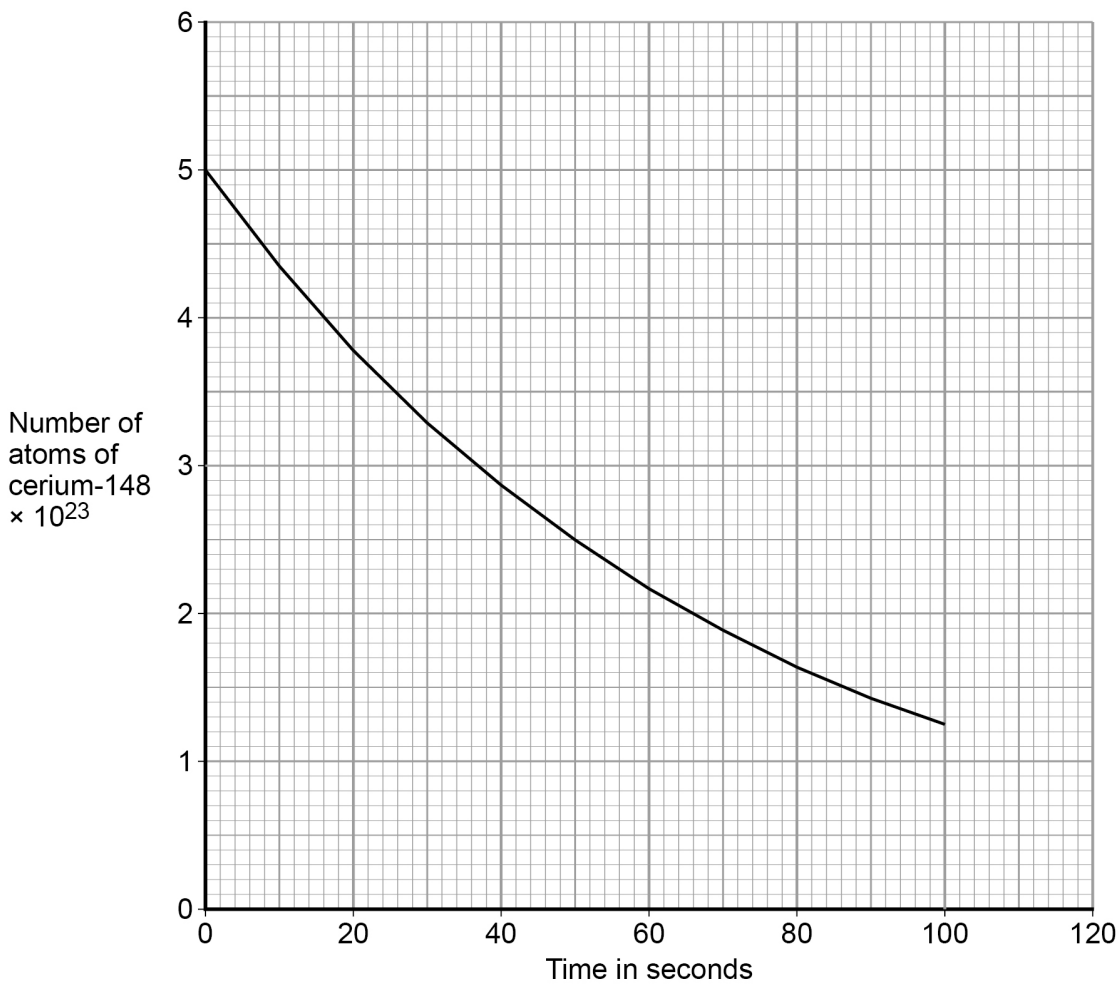
There are other isotopes of cerium which are radioactive.

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



6.4.1.1 The structure of an atom

Question 02 · continued

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

6.4.1.1 The structure of an atom

Question 03

November 2020 | 8464/P/1H | Original Q2

0 2 Different radioactive isotopes emit different types of nuclear radiation.

A polonium-210 (Po) nucleus emits an alpha particle (α) and turns into a lead (Pb) nucleus.

This can be represented by the equation:

$$^{210}_{84}Po \longrightarrow {}^{A}_{Z}Pb + \alpha$$

0 2 . 1 What is the value of A in the equation?

[1 mark]

Tick (✓) **one** box.

A = 206 ☐ A = 208 ☐ A = 210 ☐ A = 211 ☐

0 2 . 2 What is the value of Z in the equation?

[1 mark]

Tick (✓) **one** box.

Z = 80 ☐ Z = 82 ☐ Z = 85 ☐ Z = 86 ☐

Question 2 continues on the next page

Question 03 · continued

0 2 . 3 A strontium-89 nucleus (Sr) emits a beta particle (β) and turns into an yttrium nucleus (Y).

This can be represented by the equation:

$$^{89}_{38}\mathrm{Sr} \longrightarrow {}^{A}_{Z}\mathrm{Y} + \beta$$

What are the values of A and Z in the equation?

[2 marks]

A = _____

Z = _____

0 2 . 4 Gamma radiation is another type of nuclear radiation.

What does gamma radiation consist of?

[1 mark]

Tick (✓) **one** box.

- High energy neutrons ☐
- Electromagnetic waves ☐
- Particles with no charge ☐
- Positively charged ions ☐

6.4.1.1 The structure of an atom

Question 03 · continued

0 2 . 5 Explain the differences between the properties of alpha, beta and gamma radiations.

[6 marks]

11

6.4.1.1 The structure of an atom

Question 04

November 2021 | 8464/P/1H | Original Q1

0 1 **Figure 1** shows a mobile phone with its battery removed.

Figure 1



A student measured the potential difference across the battery and then put the battery into the phone.

0 1 . 1 What is the equation linking current (I), potential difference (V) and resistance (R)?

[1 mark]

Tick (✓) **one** box.

- $I = V R$ ☐
- $R = I V$ ☐
- $V = I R$ ☐
- $V = I^2 R$ ☐

Question 1 continues on the next page

6.4.1.1 The structure of an atom

Question 04 · continued

0 1 . 2 The current in the electronic circuit in the mobile phone was 0.12 A.

The potential difference across the battery was 3.9 V.

Calculate the resistance of the electronic circuit in the mobile phone.

[3 marks]

Resistance = _____ Ω

6.4.1.1 The structure of an atom

Question 04 · continued

0 1 . 3 Write down the equation which links energy (E), power (P) and time (t).

[1 mark]

0 1 . 4 The battery was fully charged when it was put into the mobile phone.

The battery discharged when the mobile phone was switched on.

The average power output of the battery as it discharged was 0.46 watts.

The time taken to fully discharge the battery was 2500 minutes.

Calculate the energy transferred by the battery.

[3 marks]

Energy transferred = _____ J

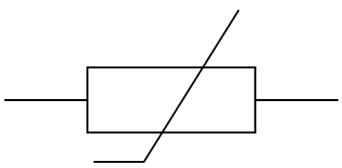
Question 1 continues on the next page

Question 04 · continued

The mobile phone includes a sensor to monitor the temperature of the battery.

Figure 2 shows the circuit symbol for a component used in the sensor.

Figure 2



0 1 . 5 What component does the circuit symbol shown in **Figure 2** represent?

[1 mark]

0 1 . 6 The temperature of the component in **Figure 2** increases.

The potential difference across the component remains constant.

Explain what happens to the current in the component.

[2 marks]

11

6.4.1.1 The structure of an atom

Question 05

November 2021 | 8464/P/1H | Original Q2

0 2 A radioactive source emits alpha, beta and gamma radiation.

0 2 . 1 An alpha particle is the same as a helium nucleus.

How many times bigger is the radius of a helium atom than the radius of an alpha particle?

[1 mark]

Tick (✓) **one** box.

- Less than 100 times bigger ☐
- Exactly 5000 times bigger ☐
- More than 10 000 times bigger ☐

0 2 . 2 Alpha particles can ionise atoms in the air.

What happens to an atom when it is ionised by an alpha particle?

[2 marks]

Tick (✓) **two** boxes.

- A neutron in the atom becomes a proton. ☐
- The atom becomes a positive ion. ☐
- The atom gains a neutron. ☐
- The atom gains a proton. ☐
- The atom loses an electron. ☐

Question 2 continues on the next page

6.4.1.1 The structure of an atom

Question 05 · continued

0 2 . 3 A spark detector is a device that can be used to detect alpha radiation.

A spark detector works by alpha particles ionising atoms in the air near a wire mesh.

A large potential difference creates a spark when the air near the wire mesh is ionised.

Suggest why a spark detector **cannot** detect beta radiation.

[1 mark]

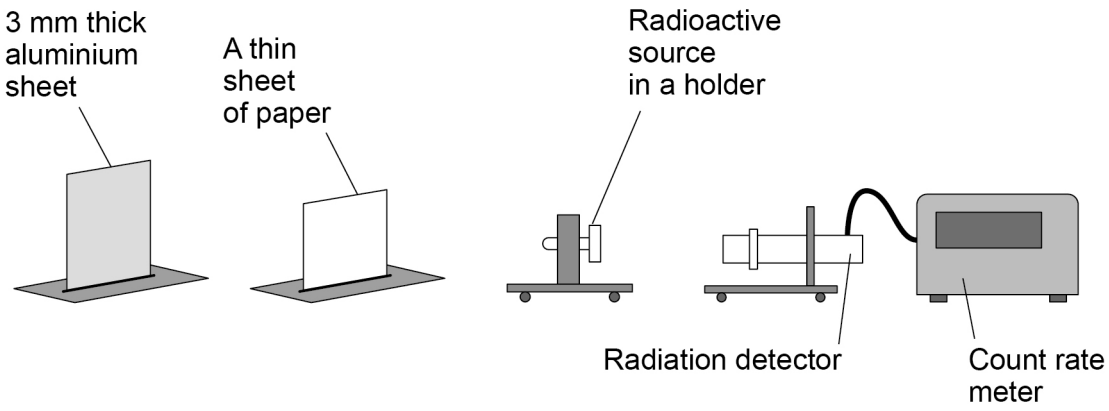
6.4.1.1 The structure of an atom

Question 05 · continued

0 2 . 4 A teacher wants to demonstrate that the radioactive source emits alpha, beta and gamma radiation.

Figure 3 shows the equipment the teacher has.

Figure 3



Describe a method the teacher could use.

[6 marks]

10

6.4.1.1 The structure of an atom

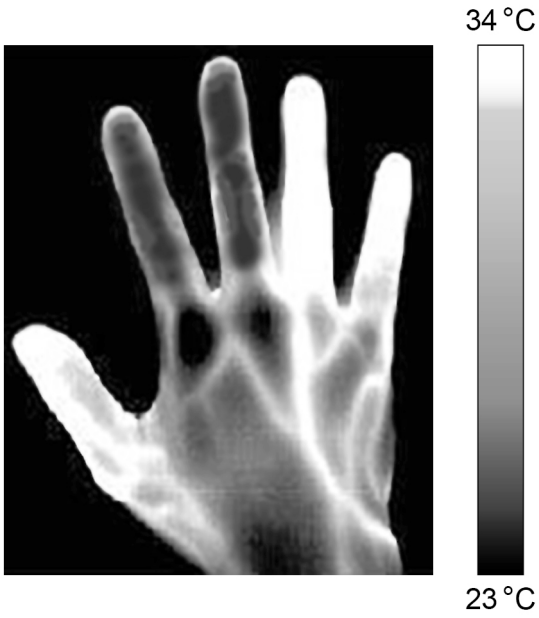
Question 06

November 2021 | 8464/P/2H | Original Q5

0 5 Different parts of the electromagnetic spectrum are used in medical imaging.

Figure 8 shows an image of a person's hand taken with an infrared camera.

Figure 8



0 5 . 1 Explain why the infrared camera is able to show that parts of the hand are at different temperatures.

[2 marks]

Question 5 continues on the next page

6.4.1.1 The structure of an atom

Question 06 · continued

0 5 . 2 Infrared has a range of wavelengths from 700 nm to 1 mm.

Which part of the electromagnetic spectrum would have waves with a wavelength of 6.5×10^{-7} m?

[1 mark]

Tick (✓) **one** box.

- Infrared ☐
- Microwaves ☐
- Radio waves ☐
- Visible light ☐

6.4.1.1 The structure of an atom

Question 06 · continued

0 5 . 3 **Figure 9** shows X-rays and gamma rays being used for medical imaging.

Figure 9

X-rays **Gamma rays**



To use X-rays for medical imaging, a machine produces a very brief burst of X-rays.

To use gamma rays for medical imaging, a radioactive isotope is injected into the patient's blood. The isotope is circulated around the body in the blood. The isotope emits gamma rays.

Compare the potential risks to a patient of using X-rays and gamma rays for medical imaging.

[4 marks]

Question 5 continues on the next page

6.4.1.1 The structure of an atom

Question 06 · continued

X-rays are produced by colliding high-energy electrons into a metal target.

The electrons have high energy because they are accelerated to high speeds.

Only a small proportion of the kinetic energy of an electron is converted into an X-ray when it collides with the metal target.

0 5 . 4 An electron is accelerated through a distance of 15 mm.

The work done on the electron is 1.2×10^{-13} J.

Calculate the force on the electron.

[3 marks]

Force = _____ N

0 5 . 5 The metal target is made from tungsten.

Tungsten has the highest melting point of any metal.

Explain why using tungsten as the metal target enables the X-ray machine to be more powerful.

[3 marks]

13

6.4.1.1 The structure of an atom

Question 07

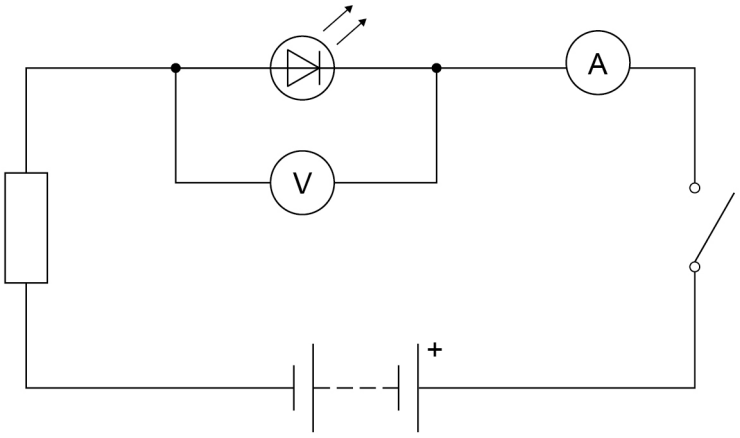
June 2022 | 8464/P/1H | Original Q5

0 5 The camera in a mobile phone uses an LED to provide light when taking a photograph.

A student investigated how the potential difference across an LED varies with the current in it.

Figure 9 shows the circuit used.

Figure 9



0 5 . 1 The student closed the switch. The voltmeter gave a reading of 5.0 V

The ammeter gave a reading of 0 mA

The LED did not emit any light.

Explain how the student should have changed the circuit to make the LED emit light.

[2 marks]

6.4.1.1 The structure of an atom

Question 07 · continued

0 5 . 2 The student changed the circuit so that the LED emitted light.

The current in the circuit was 290 mA

The power of the LED was 0.98 W

Calculate the potential difference across the LED.

Use the Physics Equations Sheet.

Give your answer to 2 significant figures.

[5 marks]

Potential difference (2 significant figures) = _____ V

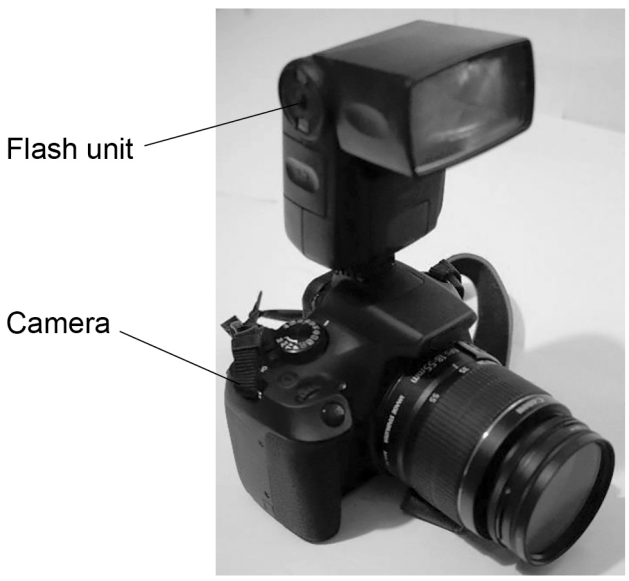
Question 5 continues on the next page

Question 07 · continued

A traditional camera uses a flash unit to provide light.

Figure 10 shows a flash unit on a traditional camera.

Figure 10



0 5 . 3 The flash unit emits light from xenon gas in a fluorescent tube.

What happens when a xenon atom emits light?

[1 mark]

Tick (✓) **one** box.

- Electrons in the atom fall to a lower energy level. ☐
- Electrons in the atom move to a higher energy level. ☐
- Electrons leave the atom, causing ionisation. ☐
- Electrons transfer to the atom from the electrical circuit. ☐

6.4.1.1 The structure of an atom

Question 07 · continued

0 5 . 4 When the flash unit is used there is a mean potential difference of 200 V across the fluorescent tube.

The flash of light lasts for 2.8×10^{-4} s

1.4 J of energy is transferred.

Calculate the mean current.

Use the Physics Equations Sheet.

[6 marks]

Mean current = _____ A

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6.4.1.1 The structure of an atom

Question 08

June 2022 | 8464/P/1H | Original Q6

0 6 A smoke detector contains a source of alpha radiation in a plastic case.

0 6 . 1 A source of beta radiation in a smoke detector would be more hazardous than a source of alpha radiation.

Explain why.

[2 marks]

0 6 . 2 Actinium (Ac) is one source of alpha radiation.

An actinium (Ac) nucleus emits an alpha particle (α) and turns into a francium (Fr) nucleus.

This can be represented as:

$$^{A}_{Z}Ac \longrightarrow {}^{223}_{87}Fr + \alpha$$

Determine the values of **A** and **Z**.

[2 marks]

A = _____

Z = _____

6.4.1.1 The structure of an atom

Question 08 · continued

0 6 . 3 A teacher wanted to find out what nuclear radiation is emitted from a source.

The teacher placed different barriers between the source and a detector.

The teacher recorded the count for 30 seconds after each barrier was put in place.

Table 2 shows the results.

Table 2

Barrier	Thickness in millimetres	Count after 30 seconds
None		985
Paper	0.1	149
Aluminium	5.0	0
Lead	20.0	0

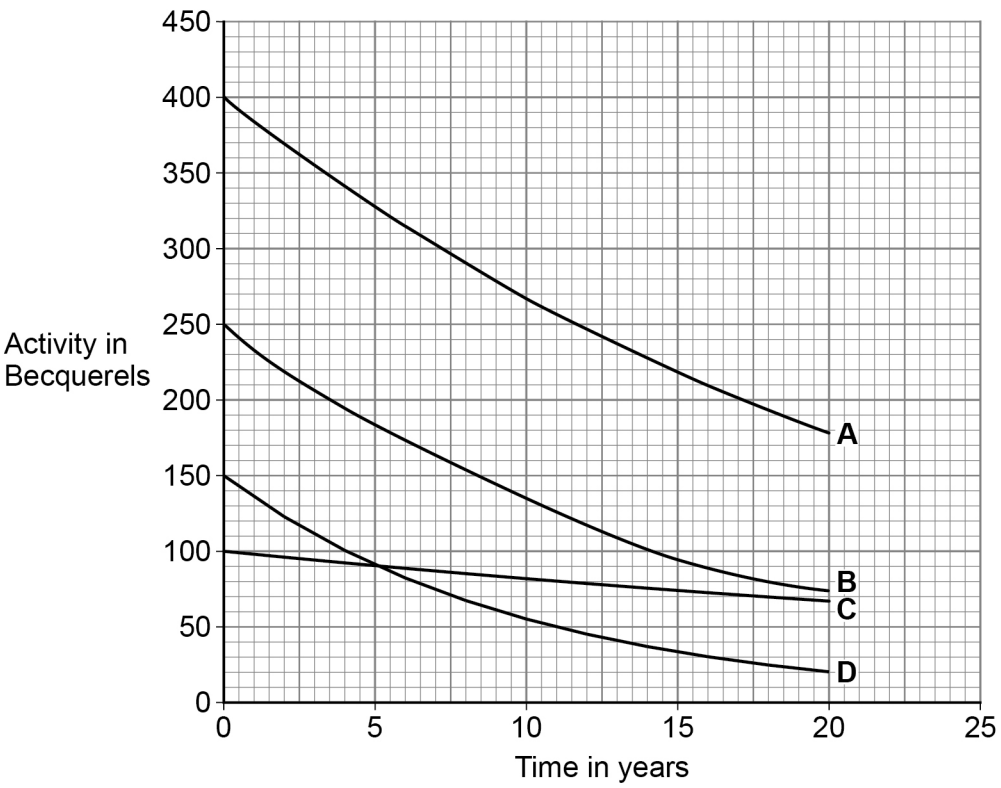
Explain what nuclear radiation was emitted by the source.

[4 marks]

Question 6 continues on the next page

0 6 . 4 **Figure 11** shows how the activity of four different radioactive isotopes, **A**, **B**, **C** and **D**, changes over time.

Figure 11



6.4.1.1 The structure of an atom

Question 08 · continued

Write the isotopes **A**, **B**, **C** and **D** in order of increasing stability of their nuclei.

Explain your answer.

[3 marks]

Least stable **Most stable**

_____ _____ _____ _____

Explanation _____

_____

_____

_____

_____

_____

11

6.4.1.1 The structure of an atom

Question 09

June 2024 | 8464/P/1H | Original Q2

0 2 Last century, scientists used evidence from the alpha particle scattering experiment to develop a new model of the atom.

In the experiment, alpha particles were directed towards a piece of gold foil.

0 2 . 1 What does an alpha particle consist of?

[1 mark]

0 2 . 2 A gold atom has the symbol $^{197}_{79}Au$.

How many neutrons are there in this gold atom?

[1 mark]

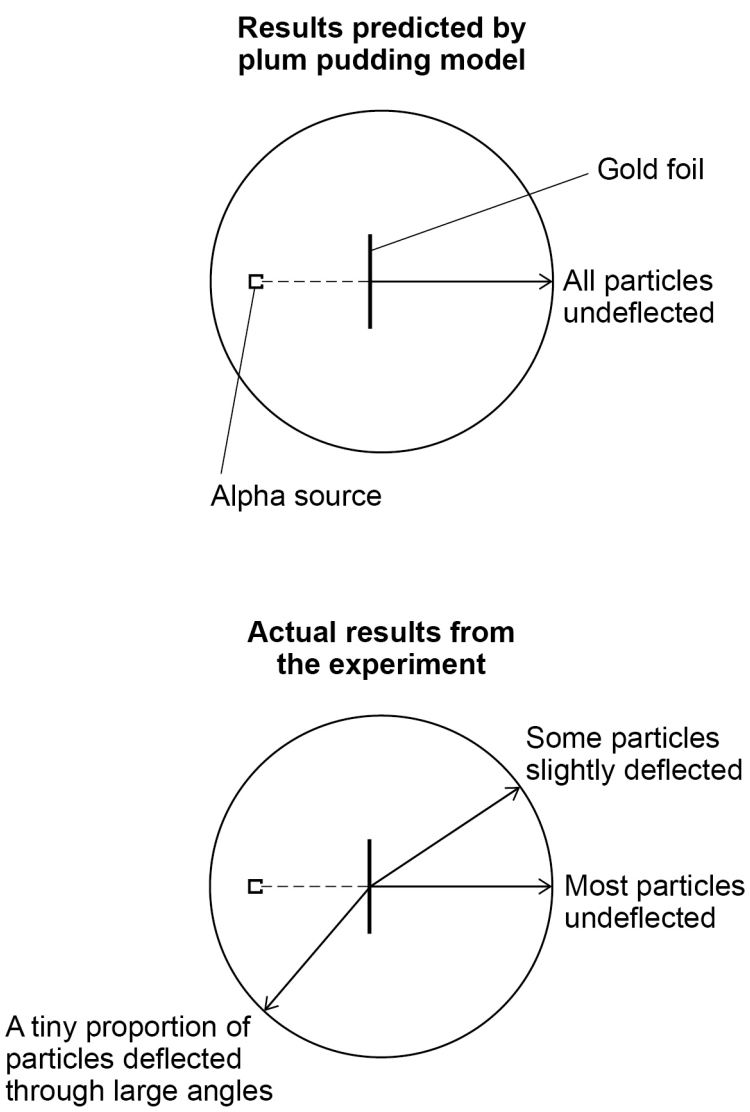
Number of neutrons = _____

Question 2 continues on the next page

0 2 . 3 The alpha particle scattering experiment led to the plum pudding model of the atom being replaced by the nuclear model.

Figure 2 shows the results predicted by the plum pudding model and the actual results from the alpha particle scattering experiment.

Figure 2



6.4.1.1 The structure of an atom

Question 09 · continued

Describe how the actual results led to the plum pudding model of the atom being replaced by the nuclear model.

You should include details of the plum pudding model and the nuclear model of the atom.

[6 marks]

0 2 . 4 Scientists did not know that neutrons existed when they first did alpha particle scattering experiments.

Which scientist did the experiments that provided evidence that neutrons exist?

[1 mark]

Tick (✓) **one** box.

Isaac Newton ☐

James Chadwick ☐

Niels Bohr ☐

9