Carbon dating

1 Carbon-14 is a radioactive isotope that occurs naturally.

Scientists use carbon-14 to help find the age of old pieces of wood.

This technique is called carbon dating.

It uses the idea of half-life.

(a) Which of these describes half-life?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** the time it takes for half of the undecayed nuclei to decay

☐ **B** the time it takes for all of the undecayed nuclei to decay

☐ **C** half the time it takes for all of the undecayed nuclei to decay

☐ **D** half the time it takes for half of the undecayed nuclei to decay

(b) Sketch a graph to show how the activity of a radioactive isotope changes with time.

Use the axes below. Start your line from point P.

(3)

(c) A scientist investigates an old wooden comb.

The activity of the carbon-14 in it is 0.55 Bq.

The estimated age of the comb is 11 400 years.

The half-life of carbon-14 is 5700 years.

(i) Calculate the activity of the carbon-14 in the comb when it was new.

(3)

activity = ... Bq

(ii) The scientist takes several readings of background radiation.

Explain why this is necessary to improve the accuracy of the investigation.

(2)

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(iii) Old objects like the comb emit a very small amount of radiation.

The activity from the comb is about the same as comes from background radiation.

Scientists have stopped measuring the activity of carbon-14 for carbon dating.

Instead, they can measure the mass of undecayed carbon-14 left in the sample.

Suggest a reason for this change.

(1)

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(Total for Question 4 = 10 marks)

Ionising radiation

2 Alpha, beta and gamma are types of ionising radiation.

(a) State **two** ways in which gamma radiation is different from alpha radiation.

(2)

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(b) (i) Complete the sentence by putting a cross (☒) in the box next to your answer.

A beta particle is emitted by

(1)

☐ **A** an alpha particle

☐ **B** a fusion particle

☐ **C** a gamma ray

☐ **D** an unstable nucleus

(ii) Complete the sentence by putting a cross (☒) in the box next to your answer.

A beta particle has an identical charge to

(1)

☐ **A** an alpha particle

☐ **B** an electron

☐ **C** a neutron

☐ **D** a nucleus

(c) Explain how an atom becomes ionised by radiation.

(2)

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*(d) The removable lens of this old camera has four pieces of glass in it.

One of the pieces of glass is radioactive. Its surface is covered with a thin layer of magnesium fluoride.

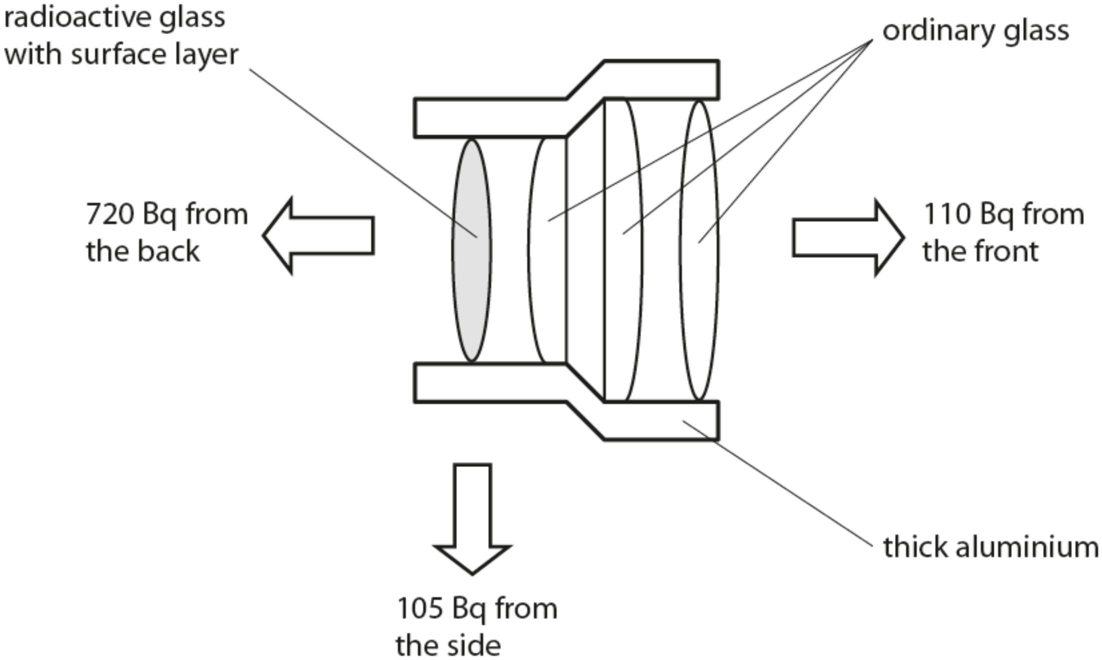
Radioactive isotopes in the glass emit alpha, beta and gamma radiation in all directions.

A scientist removes the lens from the camera. She measures the radiation coming from the back, front and side of the lens.

The amount of radiation is different in each direction.

No alpha radiation is detected.

The readings are shown on the diagram.



Explain why the readings in the three directions are different.

(6)

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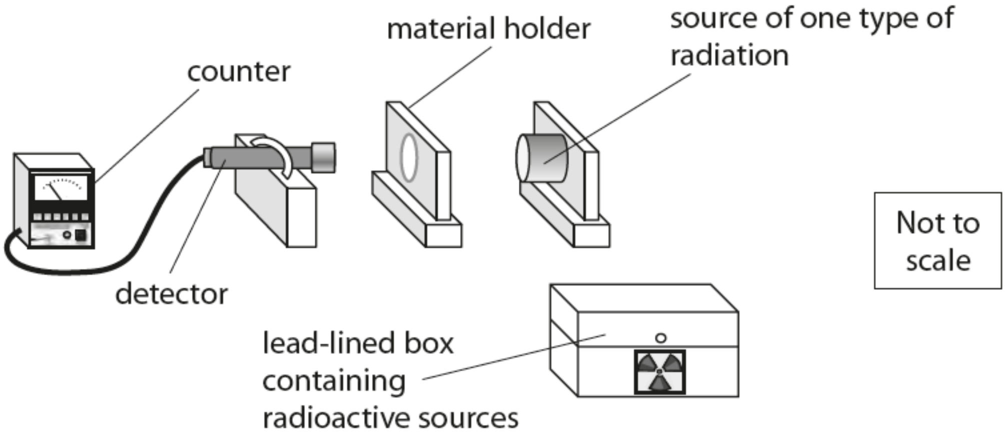
(Total for Question 6 = 12 marks)

3 (a) A student watches a radioactivity demonstration.

The demonstration uses this arrangement.



The teacher puts different materials in the holder.
Then she measures the radiation entering the detector.
Here are the results.

material in the holder	radiation entering detector (counts per minute)
nothing (only air)	121
paper	17
aluminium	17
thick lead	17

(i) Complete the sentence by putting a cross (☒) in the box next to your answer.

The radiation from the source is

(1)

☐ **A** alpha particles

☐ **B** beta particles

☐ **C** gamma rays

☐ **D** X-rays

(ii) The teacher returns the radioactive source to the box.

Suggest why the box is lined with lead.

(1)

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(iii) The counter still gives a reading.
The teacher says this is caused by background radiation.

State **one** source of background radiation.

(1)

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(iv) The teacher takes precautions to protect her students from the radiation emitted by the radioactive sources.

State **two** suitable precautions that protect the students.

(2)

1 ....

2 ....

(b) Radon is a radioactive gas which emits alpha particles.

(i) A sample of air contains 6 mg of radon.
Radon has a half-life of 4 days.

Calculate the mass of the radon remaining after 8 days.
Show your working.

(2)

mass remaining after 8 days = ... mg

(ii) Some places have rocks which release radon gas.
Explain why people living in these places may have an increased risk of long-term health problems.

(2)

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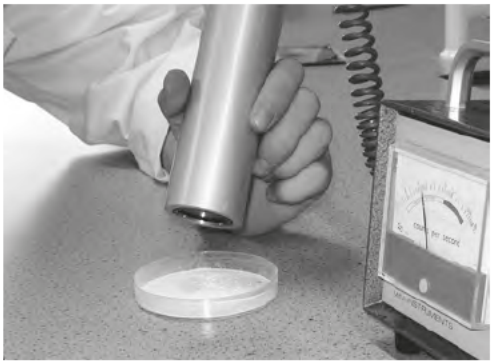
(Total for Question 2 = 9 marks)

Measuring radioactivity

4 (a) A scientist uses a Geiger counter to measure the radioactivity of a sample.



She writes down the results in her notebook.
The Geiger counter gives a count rate of 120 counts per minute.
The average background radiation in her laboratory is 10 counts per minute.

(i) What should she write down for the count rate of this sample?

Put a cross (☒) in the box next to your answer.

(1)

☐ **A** 12 counts per minute

☐ **B** 110 counts per minute

☐ **C** 130 counts per minute

☐ **D** 1200 counts per minute

(ii) Name **one** source of background radiation.

(1)

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(iii) Explain why some people are exposed to more background radiation than others.

(2)

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(iv) Complete the sentence by putting a cross (☒) in the box next to your answer.

The recommended safe limit for exposure to radiation has been reduced over the last 80 years.
This is because now

(1)

☐ **A** better instruments allow scientists to make measurements more quickly

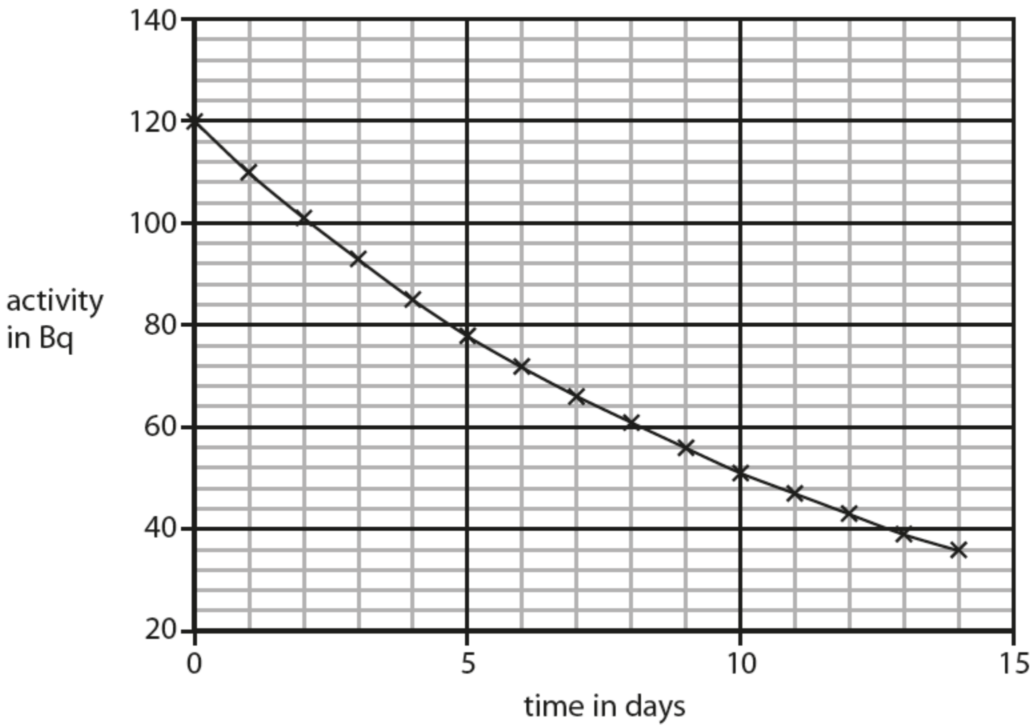
☐ **B** global warming has increased the rate of decay of radioactive materials

☐ **C** humans release more radioactive materials into the environment

☐ **D** scientists have a better understanding of the dangers of radiation

(b) After the accident at the Fukushima nuclear plant in Japan, some drinking water became contaminated with radioactive iodine-131.

The graph shows how the activity of a sample of iodine-131 changes over two weeks.



(i) Use the graph to estimate the half-life of the iodine-131.
Show your working clearly.

(2)

half-life = ... days

(ii) The recommended safe limit for a sample of this size is 100 Bq.

How long did it take for the activity of the sample to decay until it was below the safe limit?

(1)

time taken = ... days

(iii) When iodine-131 decays, it emits beta radiation.

State one possible danger to health from exposure to beta radiation.

(1)

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....

(Total for Question 2 = 9 marks)

5 (a) Figure 3 shows the structure of an oxygen-14 atom.

(i) Complete the four labels on Figure 3.

(4)

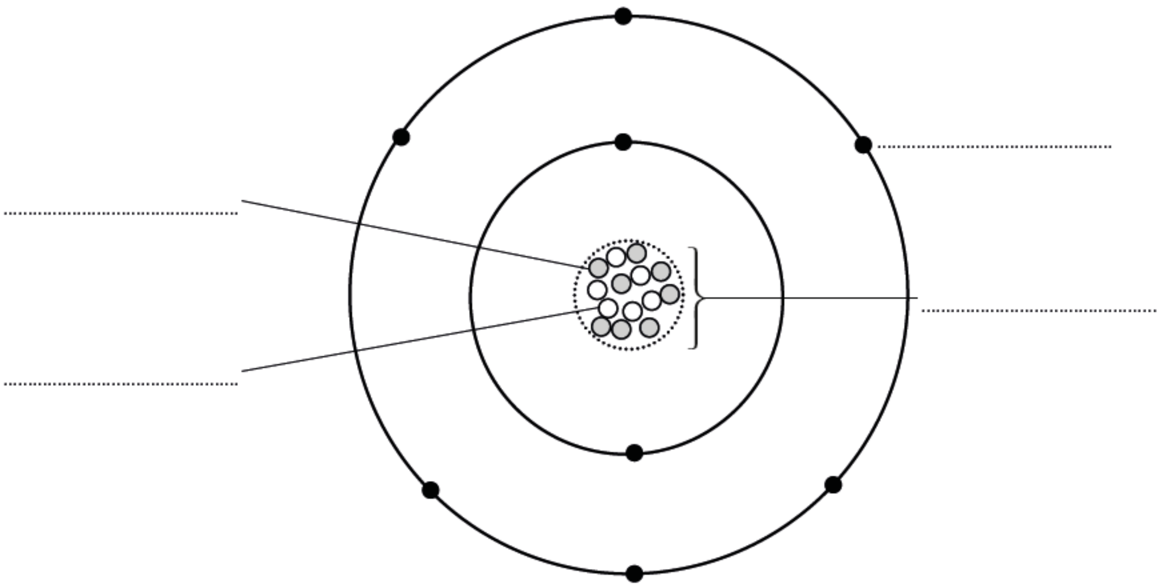

Figure 3

(ii) Which of these particles has a negative charge?

(1)

☒ **A** alpha particle

☒ **B** electron

☒ **C** neutron

☒ **D** nucleus

(iii) State the overall charge of the oxygen-14 atom.

(1)

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(b) A teacher uses a Geiger-Müller tube and a counter to measure background radiation.

The reading on the counter tube is 34 counts per minute.

(i) The teacher puts a source of beta radiation 15 cm in front of the same Geiger-Müller tube.

The reading on the counter tube is now 468 counts per minute.

Calculate how much radiation detected by the Geiger-Müller tube comes from the source of beta radiation.

(1)

.... counts per minute

(ii) The teacher puts a thick sheet of aluminium between the source of beta radiation and the Geiger-Müller tube.

Estimate the reading on the counter tube.

(1)

.... counts per minute

(iii) Give a reason why the answer to (ii) is only an estimate.

(1)

....

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(Total for Question 3 = 9 marks)