1 (a) Here are four uses of radioactivity.
Draw a line from each one of them to the type of radiation it uses.

Each type of radiation may be chosen once, more than once or not at all.

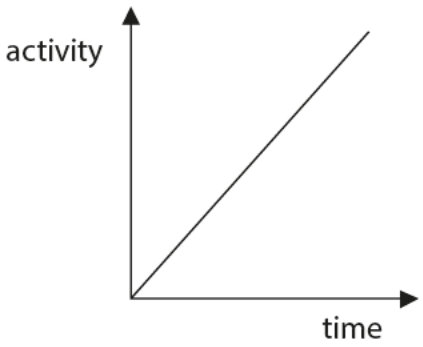
(4)

Use of radioactivity	**Type of radiation it uses**
sterilisation of medical equipment	alpha
household fire (smoke) alarm	beta
gauging thickness of cardboard	gamma
irradiating food	

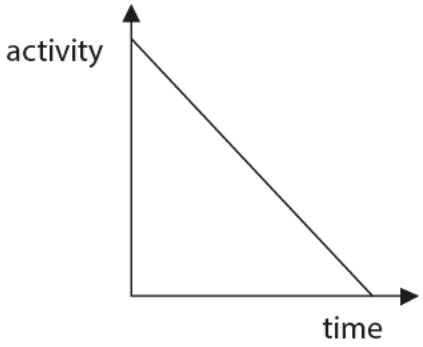
(b) Which graph best shows how the activity of a radioactive isotope changes with time?

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

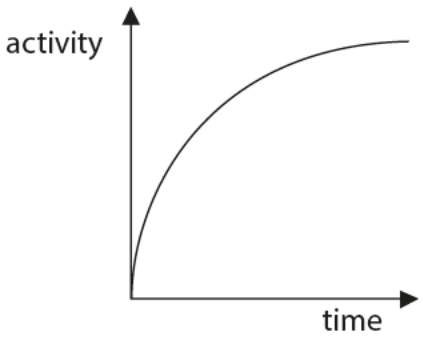
(1)



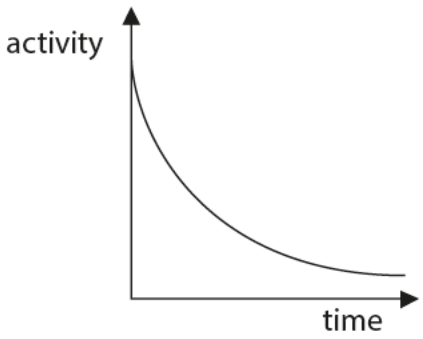
☒ **A**



☒ **B**



☒ **C**



☒ **D**

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

The unit of activity of a radioactive isotope is the

(1)

☒ **A** americium

☒ **B** becquerel

☒ **C** einstein

☒ **D** radium

(d)

Marie Curie investigated radioactivity over 100 years ago.



She often carried radioactive materials in her pocket.
She stored them in her desk drawer.
She liked the coloured light they gave off.
Marie probably died from exposure to their radiation.

Describe **two** precautions that scientists now take when they use radioactive materials.

(2)

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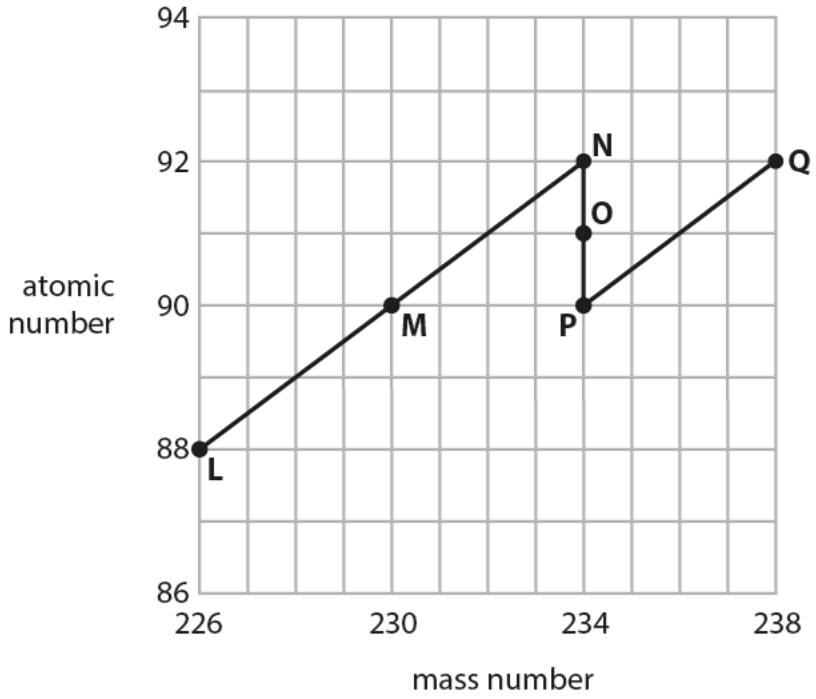
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(Total for Question 1 = 8 marks)

Uranium-238

2 Uranium-238 is an isotope of uranium. It may undergo either radioactive decay or nuclear fission.

A nucleus of uranium-238 is shown as **Q** in the chart.



(a) State **two** letters from the chart which show isotopes of the same element.

(1)

and

(b) Explain what happens when **Q** decays to **P**.

(2)

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(c) Explain what happens when **P** decays to **O**.

(2)

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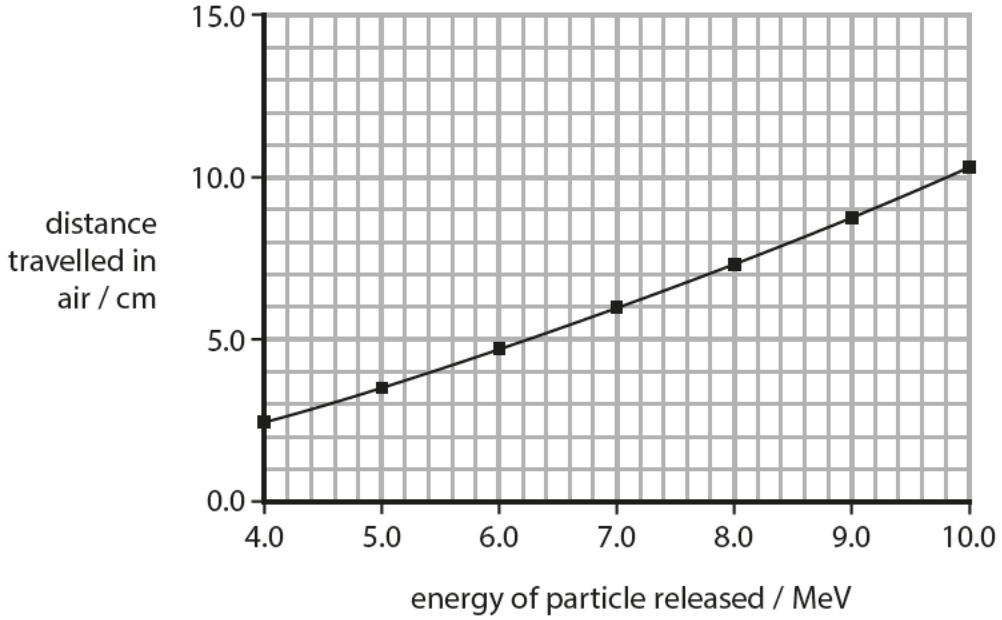
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(d) Particles released during radioactive decay can have different energies.

A suitable unit for these energies is MeV.
For one type of decay, the particles released have energies between 4.0 MeV and 10.0 MeV.
The graph shows how far the particles with these energies travel in air.



(i) State the name of this type of particle.

(1)

.....

(ii) Use information from the graph to describe how the distance travelled in air depends on the energy of the particle.

(2)

.....

.....

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(e) Uranium-238 can only undergo nuclear fission by absorbing fast neutrons.

The fission emits neutrons which very quickly lose their energy.

Suggest why the fission of uranium-238 does not produce a chain reaction. **(2)**

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.....

(Total for Question 4 = 10 marks)

Radioactivity

3 (a) An underground oil pipe starts to leak oil.
To find the leak, a technician adds a gamma source to the oil flowing in the pipe.

Describe how the technician can find the position of the leak.

(2)

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(b) Which of these is correct for half-life?

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

(1)

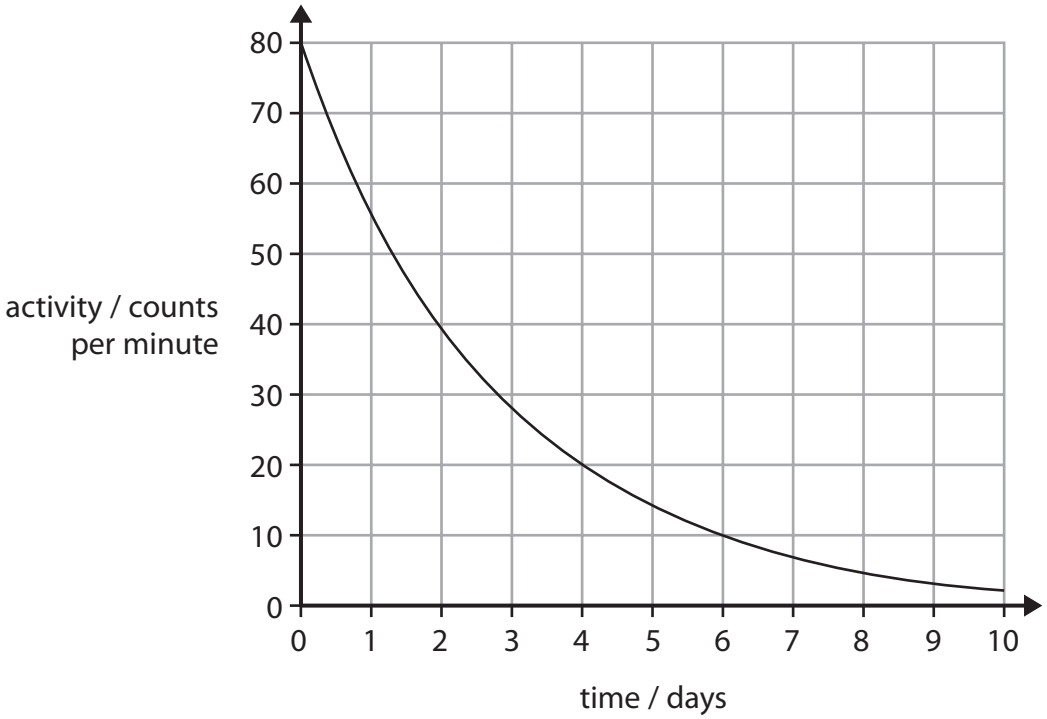
☒ **A** It is half the time for all the atoms to decay

☒ **B** It is the time it takes for an atom to half decay

☒ **C** It is the time it takes for half an atom to decay

☒ **D** It is the time it takes for half the atoms to decay

(c) The graph shows how the activity of a sample of a radioactive material changes with time.
The sample has an initial activity of 80 counts per minute.



(i) Use the graph to find the half-life of the material.

(1)

half life = days

(ii) Another sample of the material has an initial count rate of 40 counts per minute.

Sketch, on the same axes, the activity of this sample for the first 4 days.

(2)

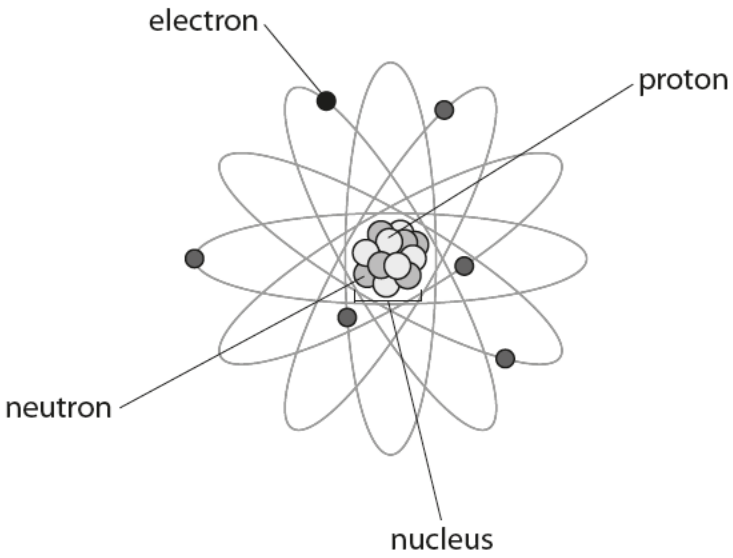
*(d) Some scientists carry out an experiment to measure the radioactivity from a source to be used in a factory.
They measure the background radiation before and after their experiment.
They take the background count at the same place as they do their experiment.

Explain how this procedure helps to make sure that the results of the experiment are valid.

(6)

(Total for Question 6 = 12 marks)

4 The diagram shows the structure of an atom.



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

The size of the charge on each electron is

(1)

☐ **A** a third of the charge on the proton

☐ **B** half the charge on the proton

☐ **C** the same as the charge on the proton

☐ **D** twice the charge on the proton

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

The atomic number of a neutral atom is always the same as the number of

(1)

☐ **A** electrons

☐ **B** electrons and neutrons

☐ **C** protons and neutrons

☐ **D** neutrons

(b) The element radium has a radioactive isotope, radium-226.

This can be written as $^{226}_{88}Ra$.

This radioactive isotope emits alpha particles.

The alpha particle has a mass number of 4 and contains two protons.

Using the numbers in the box complete the following sentences.

82	84	86	90	222	224	228	230

(i) When an alpha particle is emitted by $^{226}_{88}Ra$ the mass number becomes .....

(1)

(ii) When an alpha particle is emitted by $^{226}_{88}Ra$ the atomic number becomes .....

(1)

(c) Describe how the emissions from radioactive substances can be dangerous to living things.

(2)

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(d) Explain **one** precaution that is taken in hospitals to limit the risks of exposure to radiation.

(2)

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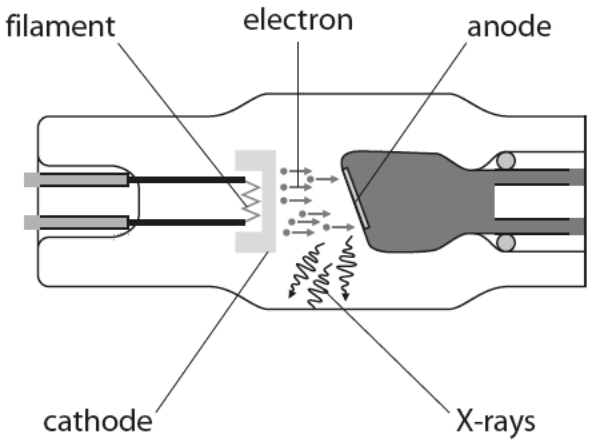
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(Total for Question 1 = 8 marks)

X-rays

5 (a) The diagram shows X-rays being produced when fast moving electrons hit a metal target.



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

The X-rays that have most energy have the

(1)

☒ **A** greatest mass

☒ **B** highest frequency

☒ **C** highest speed

☒ **D** longest wavelength

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

Electrons travel to the target because it is

(1)

☒ **A** magnetised

☒ **B** negatively charged

☒ **C** neutral

☒ **D** positively charged

(iii) Explain wh

(2)

.....

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.....

.....

(iv) Suggest why there must be a vacuum in the glass tube.

(1)

.....

.....

(b) The potential difference between the filament and metal target in an X-ray tube is 40 kV.
The charge on an electron is 1.6×10^{-19} C and its mass is 9.1×10^{-31} kg.

Calculate the speed of an electron as it reaches the target.

(3)

speed of electron = ... m/s

(Total for Question 2 = 8 marks)