Radioactivity – 2019 June

1. 0625/31/M/J/19/No.12

(a) Use words from the box to complete the sentences about the charges in an atom. Words can be used once, more than once or not at all.

negative	neutral	positive

The charge on the nucleus of an atom is .....

The charge on a proton is .....

The charge on electrons orbiting the nucleus is .....

[3]

(b) A nucleus of radium-226 has the nuclide notation shown.

$$^{226}_{88}Ra$$

(i) Determine the number of protons in a nucleus of radium-226.

..... [1]

(ii) Determine the number of neutrons in a nucleus of radium-226.

..... [1]

(iii) Radium has another isotope, radium-223.

Write the nuclide notation for radium-223 in the space.

[1]

(c) Radium-226 has a half-life of 1600 years.

A sample contains 8.0 mg of radium-226.

Calculate the time for the sample to decay until only 1.0 mg of radium-226 remains.

time = ... years [2]

[Total: 8]

2. 0625/32/M/J/19/No.12

(a) Radioactive emission is a random process.

Explain the meaning of the word *random*.

.....

..... [1]

(b) The table compares three types of radioactive emission.

emission	relative ionising ability	relative penetrating ability
alpha		
beta		
gamma		

Table 12.1

Complete the table by choosing words from the box.

high	low	medium

[3]

(c) A radioactive substance decays by emitting an α-particle.

An α-particle can be represented as ${}^{4}_{2}\alpha$.

Draw a labelled diagram showing the composition of an α-particle.

[3]

[Total: 7]

3. 0625/33/M/J/19/No.11

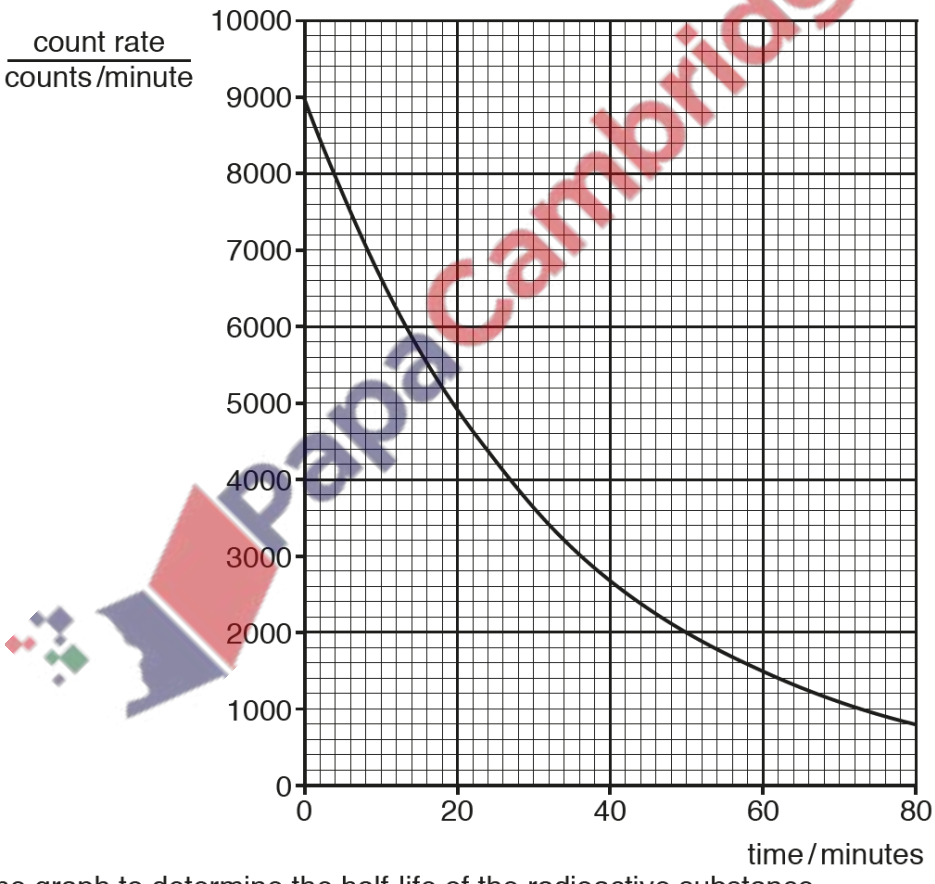
(a) Table 11.1 includes information about the properties of three types of naturally occurring, nuclear radiation.

Table 11.1

type of radiation	charge	mass (atomic mass units)	nature
	0	0	electromagnetic wave
α (alpha)	+2		helium-4 nucleus
		1/2000	

Complete the table. [4]

(b) The graph shows the decay curve for a radioactive substance.



Use the graph to determine the half-life of the radioactive substance.

half-life = ... minutes [3]

[Total: 7]

4. 0625/41/M/J/19/No.9

(a) Fig. 9.1 shows a beam of α-particles moving towards a thin sheet of gold in a vacuum.

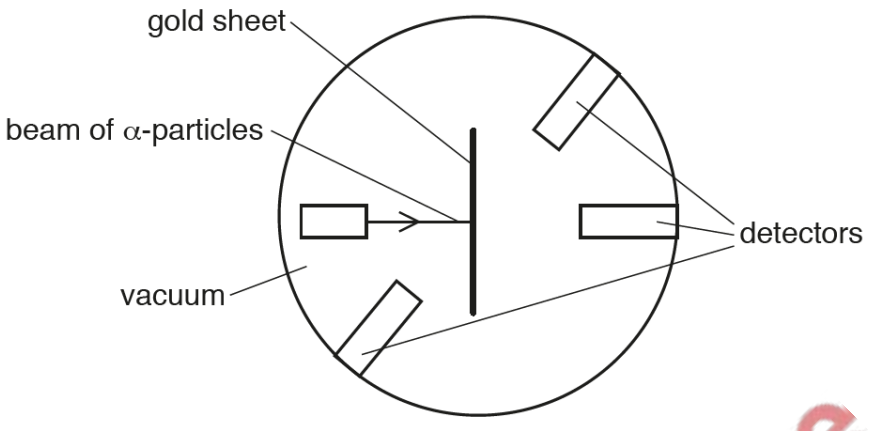


Fig. 9.1

Detectors in the region surrounding the thin gold sheet detect the α-particles and determine the number of particles that travel in various directions.

State and explain what can be deduced from the following observations.

(i) The majority of the α-particles pass through the gold sheet undeflected and are detected on the far side.

deduction .....

explanation .....

..... [2]

(ii) A small number of α-particles are deflected as they pass through the gold sheet.

deduction .....

explanation .....

..... [2]

(iii) A very small number of α-particles are deflected through very large angles or return back the way they came.

deduction .....

explanation .....

..... [2]

(b) A beam that consists of both α-particles and β-particles is passed through a region of space where there is a magnetic field perpendicular to the direction of the beam.

State **two** ways in which the deflection of the α-particles differs from that of the β-particles.

1. .....

2. .....

[2]

[Total: 8]

5. 0625/42/M/J/19/No.11

(a) A radon-222 nucleus contains 86 protons and 136 neutrons. It decays by emitting an α-particle and becomes a nucleus of an isotope of polonium. The symbol for radon is Rn and the symbol for polonium is Po.

Write down the nuclide equation for this decay.

[3]

(b) Carbon-14 is radioactive with a half-life of 5700 years. An animal bone is dug up in an archaeological excavation. The quantity of carbon-14 in the bone is 25% of what it was when the bone was buried.

Calculate the time that has elapsed since it was buried.

time = ... years [2]

[Total: 5]

6. **(a)** Americium (Am) is a radioactive isotope. A nucleus of americium contains 95 protons and 146 neutrons. It decays by emitting an α-particle to form a nucleus of an isotope of neptunium (Np).

Write down the nuclide equation for the decay of americium to neptunium.

[4]

(b) Ionisation smoke detectors contain americium and two small electrodes with a small voltage between them. The air between the electrodes is ionised by α-particles so that there is a small electric current between the electrodes.

(i) Suggest and explain the effect of smoke on the current between the electrodes in the smoke detector.

Suggestion: .....

.....

Explanation: .....

..... [1]

(ii) Suggest **two** reasons for using an α-particle emitter in a smoke detector.

Reason 1 .....

.....

Reason 2 .....

..... [2]

[Total: 7]

7. 0625/32/F/M/19/No.12

Astatine-210 is a radioactive material. The nucleus of astatine can be represented by the symbol shown.

$$^{210}_{85}\text{At}$$

(a) Complete the table to describe the nucleus of astatine-210.

type of particle	number of particles	charge on particle
neutron		
		positive

[4]

(b) Astatine-210 has a half-life of 8 hours.

(i) The count rate of a sample of astatine-210 is measured over 24 hours.

On Fig. 12.1, sketch a line to show how the count rate changes over the 24 hours.

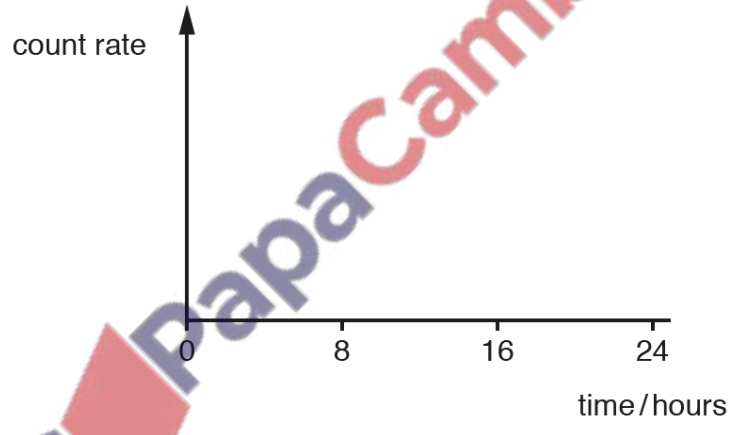


Fig. 12.1

[2]

(ii) The mass of a sample of astatine-210 is 0.500 kg.

Calculate how long it takes for 0.375 kg of the sample to decay.

decay time = ... hours [3]

[Total: 9]

8. 0625/42/F/M/19/No.11

(a) (i) One isotope of iridium-194 is represented by

$$^{194}_{77}\text{Ir}$$

This isotope decays by β-emission to a stable isotope of platinum (Pt).

Complete the nuclide equation for this decay.

$$^{194}_{77}\text{Ir} \rightarrow \begin{matrix}\cdots\cdots \\ \cdots\cdots\end{matrix}\text{Pt} + \begin{matrix}\cdots\cdots \\ \cdots\cdots\end{matrix}\beta$$

[3]

(ii) The half-life of iridium-194 is 19 hours. A sample of iridium-194 has an initial count-rate of 1100 counts/min.

Calculate the count-rate from this sample after 38 hours.

count-rate = ... [2]

(b) State **two** ways in which γ-emission differs from β-emission.

1 .....

2 .....

[2]

[Total: 7]