Radioactivity

Question Paper

Course	CIE IGCSE Physics
Section	5. Nuclear Physics
Topic	Radioactivity
Difficulty	Medium

Time Allowed	80
Score	/62
Percentage	/100

Question 1a

The isotope hydrogen-1 has a proton number of 1 and a nucleon number of 1.

Two isotopes of helium are helium-3 and helium-4.

Helium-3 has a proton number of 2 and a nucleon number of 3.

Helium-4 has a nucleon number of 4.

Complete Table 11.1 for neutral atoms of these isotopes of helium.

Table 11.1

	helium-3	helium-4
number of neutrons		
number of electrons		
mass compared to a neutral atom of hydrogen-1		

[3 marks]

Question 1b

An experiment takes place in a laboratory shielded from all background radiation. A sample of radioactive material is wrapped in aluminium foil of thickness 0.1 mm. A detector of ionising radiation placed 1 cm from the foil records a reading.

A piece of aluminium of thickness 5 mm is placed between the detector and the foil. The detector reading drops to zero.

State and explain any type of radiation passing through the aluminium foil.

[3 marks]

Question 2a

This notation represents the nucleus of a neutral atom of carbon-14.

$$^{14}_{6}C$$

State the number of:

(i)   protons in the nucleus of an atom of carbon-14

[1]

(ii)   electrons orbiting the nucleus of an atom of carbon-14

[1]

(iii)   neutrons in the nucleus of an atom of carbon-14.

[1]
[3 marks]

Question 2b

Carbon-14 is an isotope of carbon. Carbon-12 is another isotope of carbon.

Compare the nucleus of carbon-14 with the nucleus of carbon-12.

State the similarities and differences.

[3 marks]

Question 2c

Scientists use carbon-14 to estimate the age of wood that is very old.

A very old sample of wood contains 1.0×10^8 carbon-14 atoms.

When the sample was new, it contained 8.0×10^8 carbon-14 atoms. The half-life of carbon-14 is 5700 years.

Estimate the age of the sample of wood.

age of wood = ... years

[3 marks]

Question 3a

Radioactive sources emit α-(alpha), β-(beta) and γ-(gamma) radiations.

State which of these types of radiation can pass through paper.

[1 mark]

Question 3b

Barium-137 is a radioactive isotope. The nuclide notation for barium-137 is

$$^{137}_{56}Ba$$

Determine the number of neutrons in a nucleus of barium-137.

number of neutrons = ...

[1 mark]

Question 3c

An isotope of barium-137 has a half-life of 3 minutes.

A radioactive source contains 36 mg of this isotope.

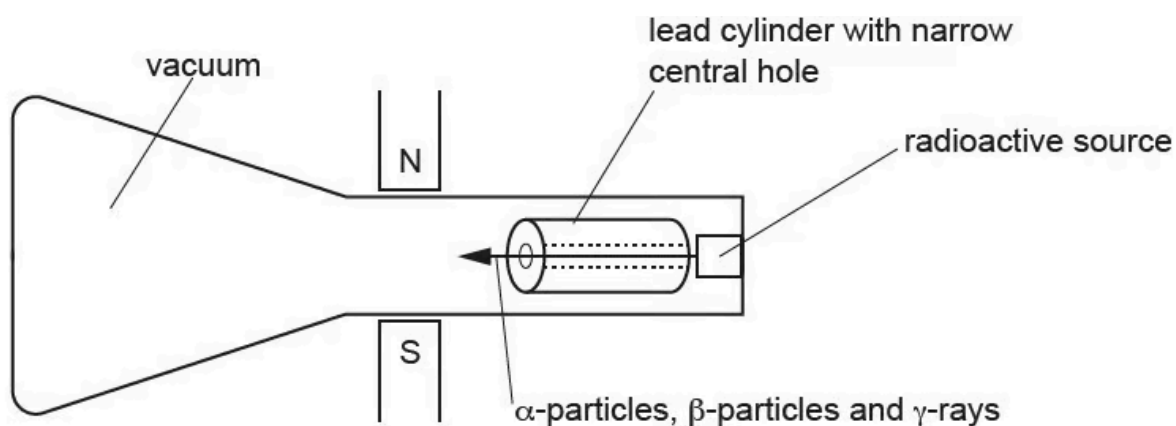Calculate the mass of the isotope that remains in the source after 9 minutes.

mass of the isotope remaining = ... mg

[3 marks]

Question 4a

Fig. 10.1 shows a vacuum tube with a radioactive source. The radioactive source emits α-particles, β-particles and γ –rays. There is a very strong magnetic field between the N pole and the S pole of the magnet.

Fig. 10.1

The lead cylinder has a narrow central hole. State and explain the effect of the lead cylinder.

[2 marks]

Question 4b

Extended tier only

Describe the paths of the α-particles, β-particles and γ -rays as they pass through the magnetic field. Explain your answers.

    (i)   α-particles

                                           [2]

    (ii)   β-particles

                                           [2]

    (iii)   γ -rays

                                           [2]

[6 marks]

Question 5a

Radioactive decay may include the emission of:

α-radiation

β-radiation

γ-radiation

(i)   From the list, state the type of radiation which has the greatest ionising effect.

[1]

(ii)   From the list, state the type of radiation which has the lowest penetrating ability.

[1]

[2 marks]

Question 5b

Extended tier only

In a factory, rollers press aluminium metal to make thin foil sheets. An automatic system for controlling the thickness of the foil uses a radioactive source. The automatic system changes the gap between the top and bottom roller. Fig. 12.1 shows the equipment.
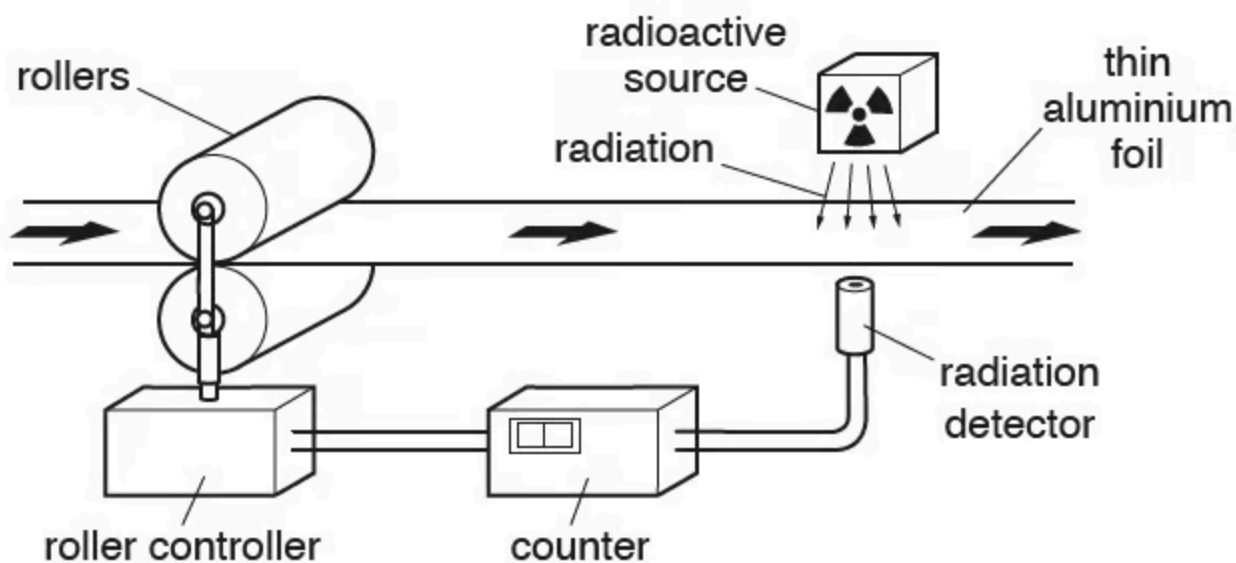
Fig. 12.1

(i)   Use your ideas about the properties of radiation to suggest and explain the type of radiation used.

type of radiation: ....

explanation: ....

[2]

(ii)   The aluminium foil passing the radiation detector is too thin. Describe how this fault affects the reading on the counter.

[1]

(iii)   Suggest how the fault in **(b)(ii)** is corrected. State what happens to the rollers.

[1]

(iv)   The source used is strontium-90. A nucleus of strontium-90 can be described as $^{90}_{38}\text{Sr}$. State the number of protons in a nucleus of strontium-90.

[1]

[5 marks]

Question 6a

Radon-222 is radioactive. It can be represented as $^{222}_{86}\text{Rn}$.
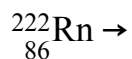
For a neutral atom of radon-222, state

       1. the number of protons, ...

       2. the number of neutrons, ...

       3. the number of electrons. ....

[3 marks]

Question 6b

Extended tier only

A radon-222 nucleus decays by α-particle emission to a polonium (Po) nucleus.

Complete the equation for the decay of radon-222.

$$^{222}_{86}\text{Rn} \rightarrow$$

[2 marks]

Question 6c

Radon-222 has a half-life of 3.8 days.

At a certain time, a sample contains 6.4×10^6 radon nuclei.

Calculate the number of α-particles emitted by the radon nuclei in the following 7.6 days.

number = ...

[3 marks]

Question 7a

The nuclide notation $^{A}_{Z}X$ describes the nucleus of one type of atom.

Draw a line from each symbol to the correct description for that symbol.

symbol	description

A

Z

X

- number of neutrons
- element symbol
- proton number
- nucleon number
- number of atoms

[3 marks]

Question 7b

(i) One radioactive isotope has a half-life of 6.0 years.

A sample of this isotope has a mass of 12 mg.

Calculate the mass of this isotope that remains in the sample after 18 years.

mass remaining = ... mg [3]

(ii) The sample decays by emitting a β-particle.

Describe the nature of a β-particle.

[2]

(iii) Describe how the nucleus of the isotope changes due to the emission of a β-particle.

[1]

[6 marks]

Question 8a

Extended tier only

A radioactive nucleus of uranium-235 decays to a nucleus of thorium and emits an α-particle.
Complete the equation.

$$^{235}_{92}U \longrightarrow ^{........}_{........} Th + ^{4}_{2} \alpha$$

[2 marks]

Question 8b

A nucleus of uranium-235 undergoes nuclear fission in a reactor.

(i)   State what is meant by nuclear fission.

[1]

(ii)   Suggest why a nuclear reactor is surrounded by thick concrete walls.

[2]

(iii)   State one environmental advantage and one environmental disadvantage of using a fission reactor to generate electrical energy in a power station.

[2]
[5 marks]

Question 8c

The thorium produced by the decay in (a) is also radioactive and has a half-life of 26 hours.

At a certain time, a pure sample of this isotope initially contains 4.8×10^9 atoms.

Calculate the number of atoms of this sample that decay in the following 52 hours.

number = ...

[3 marks]