The Nuclear atom

Question Paper 1

Level	IGCSE
Subject	Physics
ExamBoard	CIE
Topic	Atomic Physics
Sub-Topic	The nuclear atom
Paper Type	(Extended) Theory Paper
Booklet	Question Paper 1

Time Allowed: **62 minutes**

Score: **/51**

Percentage: **/100**

1 Bismuth-214 is radioactive. It has a half-life of 20 minutes.

(a) The nuclide notation for bismuth-214 is $^{214}_{83}Bi$.

State the composition of the nucleus of bismuth-214.

....

.... [2]

(b) Bismuth-214 decays by β-decay to an isotope of polonium, Po.

Complete the equation for the decay of bismuth-214.

$$^{214}_{83}\text{Bi} \rightarrow \, ^{\dots\dots}_{\dots\dots}\beta \; + \; ^{\dots\dots}_{\dots\dots}\text{Po}$$

[3]

(c) The count rate from a sample of bismuth-214 is 360 counts / s.

Predict the count rate from the sample after 60 minutes.

count rate = ... [2]

(d) State **two** of the social, economic or environmental issues involved in the storage of radioactive materials with very long half-lives.

....

....

....

.... [2]

[Total: 9]

2 In Geiger and Marsden's α-particle scattering experiment, α-particles were directed at a very thin gold foil.

Fig. 11.1 shows five of the nuclei of the atoms in one layer in the gold foil. Also shown are the paths of three α-particles directed at the foil.

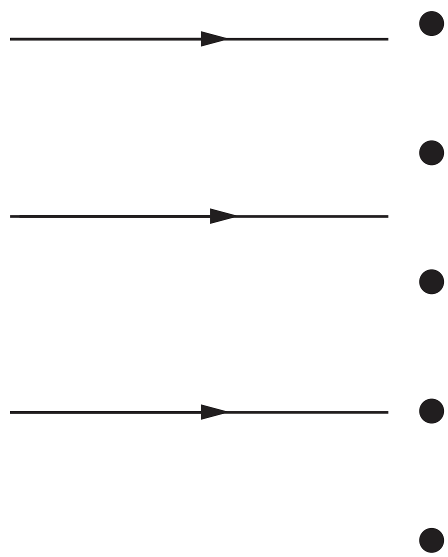

Fig. 11.1

(a) On Fig.11.1, complete the paths of the three α-particles.

(b) State the result of the experiment that shows that an atom consists of a very tiny, charged core, containing almost all the mass of the atom.

....

.... [1]

(ii) State the sign of the charge on this core. .... [1]

(iii) State what occupies the space between these charged cores.

.... [1]

(c) The nuclide notation for an α-particle is $^{4}_{2}\alpha$.
State the number of protons and neutrons in an α-particle

protons = ...

neutrons = ... [1]

[Total: 7]

3 An extremely violent nuclear reaction is taking place at the centre of the Sun. It is this reaction that enables the Sun to emit both a very large quantity of energy and an extremely large number of charged particles.

(a) Name the type of nuclear reaction taking place in the Sun.

....[1]

(b) Many of the charged particles produced by the Sun are emitted from its surface at high speeds and travel out into space.

(i) Explain why these particles constitute an electric current.

....

....[1]

(ii) State the equation that relates the electric current I to the charge Q that is flowing. Define any other terms in the equation.

....

....[1]

(c) Some of the particles emitted by the Sun travel straight towards the Earth until they enter the Earth's magnetic field. Because they constitute a current, they experience a force and are deflected.

(i) Describe the relationship between the direction of the force and

1. the direction of the current,

....[1]

2. the direction of the magnetic field.

....[1]

(ii) A negatively charged particle is travelling in a magnetic field. This is represented in Fig. 9.1. The direction of the magnetic field is into the page.

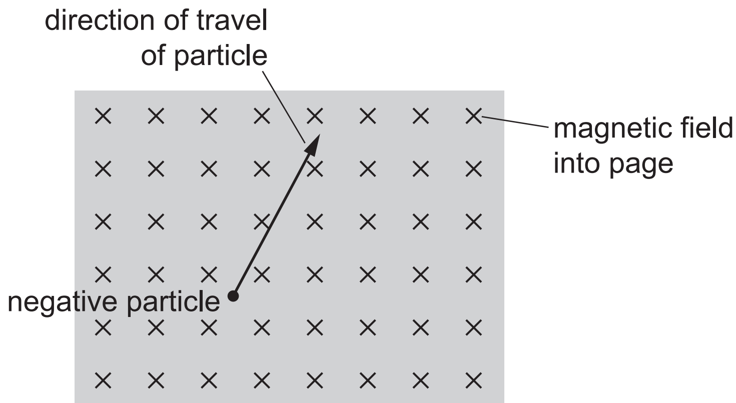

Fig. 9.1

On Fig. 9.1, draw an arrow, labelled F, to show the direction of the force that acts on the particle. [1]

[Total: 6]

4 **(a)** State, in terms of the particles in each nucleus, how the nuclei of two isotopes of the same element are different.

....[1]

(b) Fig. 11.1 shows a graph of nucleon number against proton number. The nucleus $^{212}_{83}Bi$ is plotted on the graph at the cross marked P.

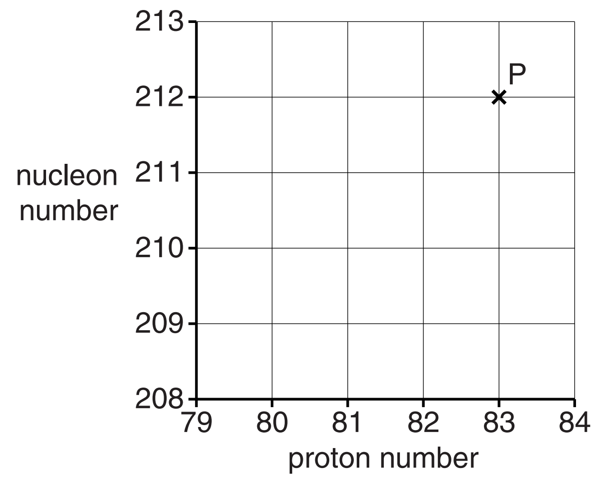

Fig. 11.1

(i) On Fig. 11.1,

1. plot a cross labelled Q for the nucleus formed when the $^{212}_{83}Bi$ nucleus emits an α-particle,

2. plot a cross labelled R for the nucleus formed when the $^{212}_{83}Bi$ nucleus emits a β-particle.

[4]

(ii) The half-life for the decay of $^{212}_{83}Bi$ is 60 minutes.

A sample of $^{212}_{83}Bi$ is placed at a fixed distance from a detector. The initial measurement of the count rate from the sample of $^{212}_{83}Bi$ is 2400 counts per minute.

Calculate the count rate from the sample 5.0 hours later.

count-rate = ...[2]

[Total: 7]

5 Uranium-238 and uranium-234 are radioactive isotopes of the element uranium.

A uranium-238 nucleus is different from a uranium-234 nucleus but both decay by the emission of an α-particle.

(a) **(i)** In terms of the particles in each, state how a nucleus of uranium-238 differs from a nucleus of uranium-234.

....

....[2]

(ii) Although the two nuclei are different, they are both nuclei of uranium.

State a property that makes these isotopes the same element.

....

....[1]

(b) When α-particles pass through air, they are more strongly ionising than β-particles.

Suggest **two** reasons why this is so.

....

....[2]

(c) In an experiment, α-particles are allowed to strike a thin gold foil in a vacuum.

Almost all the α-particles pass straight through the gold undeflected. Only a very small number of α-particles are deflected from their original path.

This result reveals certain features of the atoms of the gold.

State what is shown about atoms by the fact that

(i) most α-particles pass straight through the gold undeflected,

....

....[1]

(ii) some α-particles are deflected back the way they came.

....

....[1]

[Total: 7]

6 In a famous experiment, a beam consisting of a very large number of α-particles was projected, in a vacuum, at a very thin gold foil.

Fig. 11.1 shows the paths of three of the α-particles A, B and C travelling towards the foil.

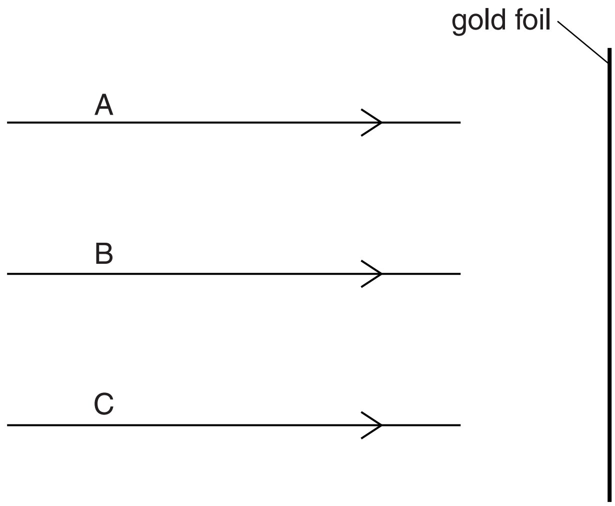

Fig. 11.1

α-particle A is travelling along a line which does not pass very close to a gold nucleus.
α-particle B is travelling along a line which passes close to a gold nucleus.
α-particle C is travelling directly towards a gold nucleus.

(a) Explain why an α-particle and a gold nucleus repel each other.

.... [1]

(b) On Fig. 11.1, draw lines with arrows to show the continuation of the paths of α-particles A, B and C. [3]

(c) State two conclusions, about gold atoms, which resulted from the experiment.

....

....

....

.... [2]

[Total: 6]

7 There are two stable, naturally occurring isotopes of hydrogen.

Common hydrogen (hydrogen-1) has a proton number of 1 and a nucleon number of 1.

Hydrogen-2 (deuterium) has a nucleon number of 2.

There is also a radioactive isotope of hydrogen called tritium (hydrogen-3), with a nucleon number of 3.

(a) Complete the table for neutral atoms of these isotopes.

	hydrogen-1	hydrogen-2 (deuterium)	hydrogen-3 (tritium)
number of protons			
number of neutrons			
number of electrons			

[3]

(b) Two samples of tritium are stored in aluminium containers of different thickness.

Sample 1 is in a container of thickness 0.5 mm and radiation can be detected coming through the container.

Sample 2 is in a container of thickness 5 mm and no radiation comes through.

(i) State the type of radiation coming through the container of Sample 1.

.... [1]

(ii) Explain your answer to **(b)(i)**.

....

....

....

.... [2]

(c) Under conditions of extremely high temperature and pressure, as in the interior of the Sun, hydrogen nuclei can join together.

(i) Name this process.

....[1]

(ii) State whether energy is released, absorbed or neither released nor absorbed during this reaction.

....[1]

(d) When a nucleus of a certain isotope of uranium is bombarded by a suitable neutron, it splits into two smaller nuclei and energy is released.

Name this process.

....[1]

[Total: 9]