Particle Physics

Question paper 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Particle & Nuclear Physics
Sub Topic	Particle Physics
Paper Type	Theory
Booklet	Question paper 3

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Uranium-236 ($^{236}_{92}U$) and Uranium-237 ($^{237}_{92}U$) are both radioactive.
Uranium-236 is an α-emitter and Uranium-237 is a β-emitter.

(a) Distinguish between an α-particle and a β-particle.

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.....

.....

.....

.....

..... [4]

(b) The grid of Fig. 7.1 shows some proton numbers Z on the x-axis and the number N of neutrons in the nucleus on the y-axis.

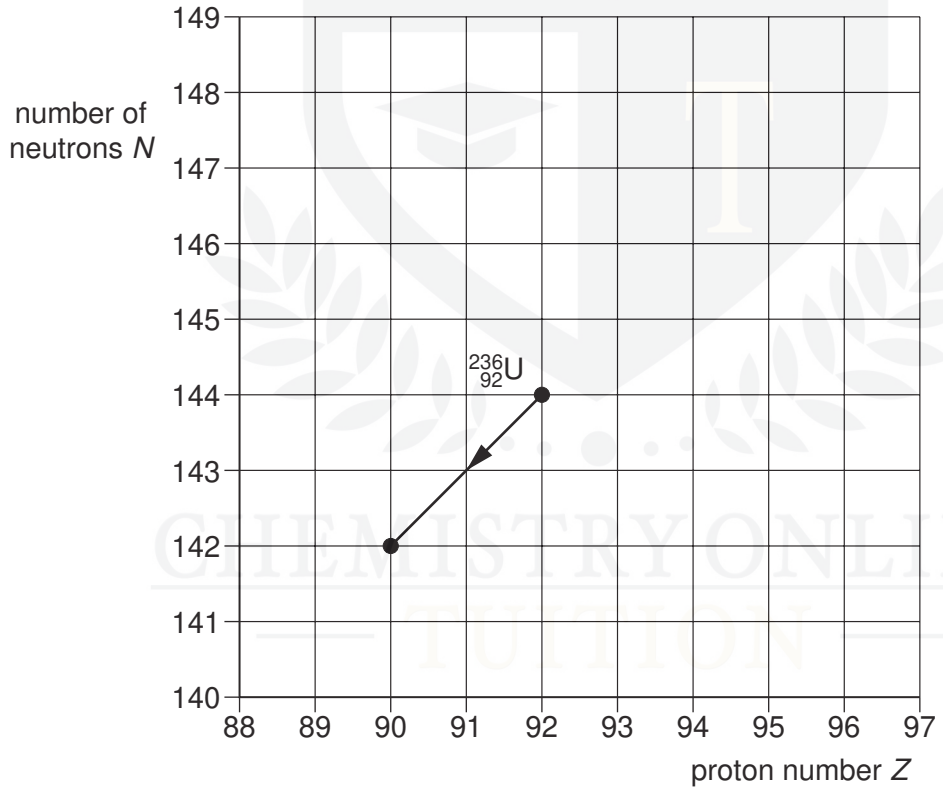

Fig. 7.1

The α-decay of Uranium-236 ($^{236}_{92}U$) is represented on the grid. This decay produces a nucleus of thorium (Th).

(i) Write down the nuclear equation for this α-decay.

.....[2]

(ii) On Fig. 7.1, mark the position for a nucleus of

1. Uranium-237 (mark this position with the letter U),

2. Neptunium, the nucleus produced by the β-decay of Uranium-237 (mark this position with the letters Np). [2]

2 **(a)** Evidence for the nuclear atom was provided by the α-particle scattering experiment. State the results of this experiment.

.....

.....

.....

..... [2]

(b) Give estimates for the diameter of

(i) an atom,

.....[1]

(ii) a nucleus.

.....[1]

3 The radioactive decay of a strontium (Sr) nucleus is represented in Fig. 7.1.

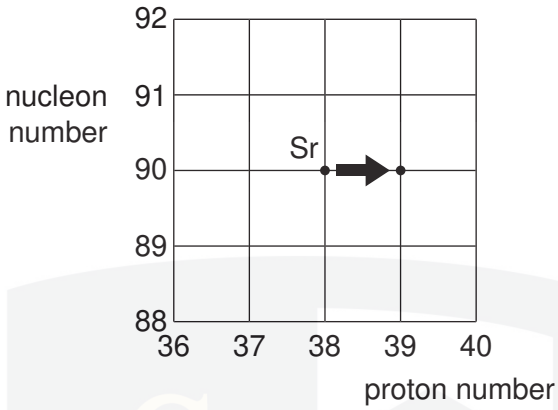

Fig. 7.1

(a) State whether Fig. 7.1 represents α-decay, β-decay or γ-decay.

.....[1]

(b) One type of radioactive decay cannot be represented on Fig. 7.1.
Identify this decay and explain why it cannot be represented.

.....

.....

.....[2]

4 The α- particle scattering experiment provided evidence for the existence of a nuclear atom.

(a) State what could be deduced from the fact that

(i) most α-particles were deviated through angles of less than 10°,

.....

.....

..... [2]

(ii) a very small proportion of the α-particles was deviated through angles greater than 90°.

.....

.....

..... [2]

(b) Fig. 7.1 shows the path AB of an α-particle as it approaches and passes by a stationary gold nucleus.

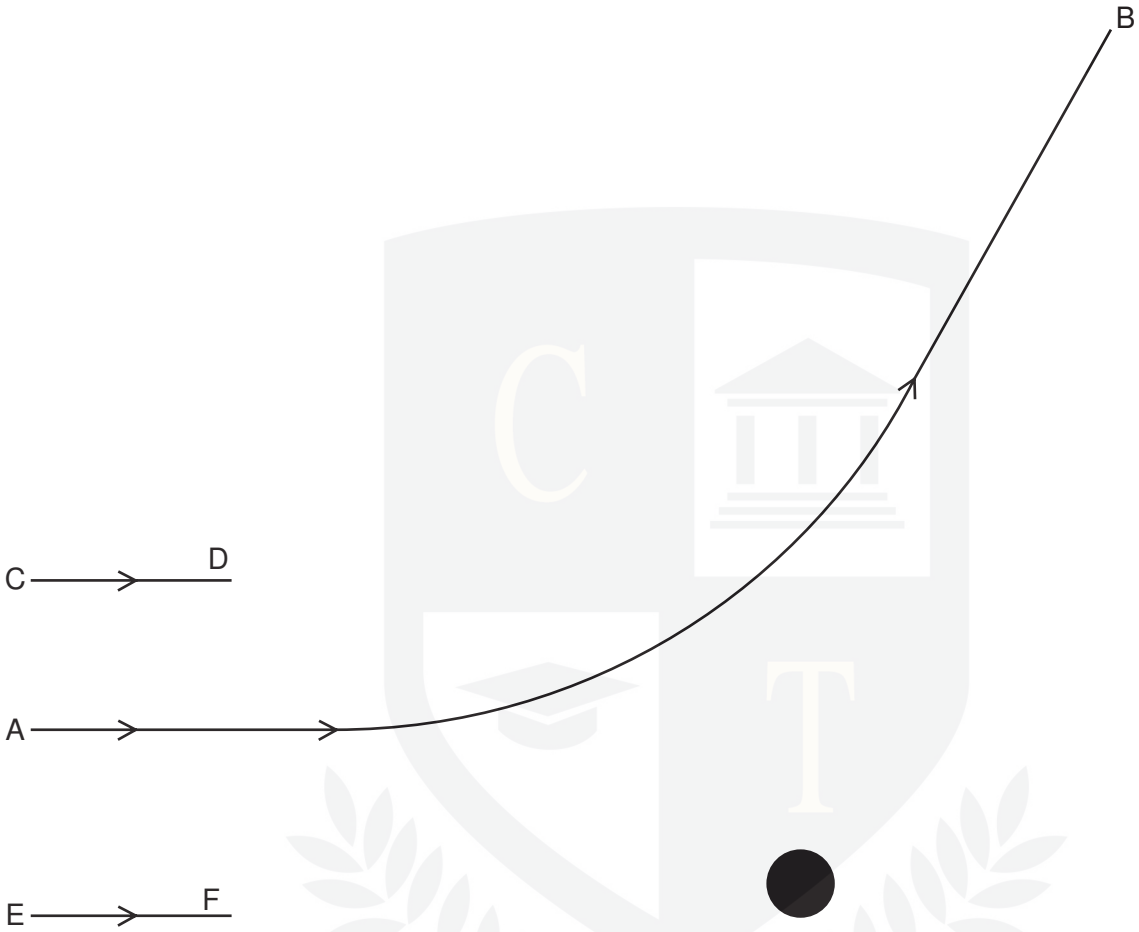

Fig. 7.1

On Fig. 7.1, draw lines (one in each case) to complete the paths of the α-particles passing by the gold nucleus when the initial direction of approach is

(i) along line CD,

(ii) along line EF.

[3]

5 One isotope of iron may be represented by the symbol

$$^{56}_{26}\text{Fe}.$$

(a) State, for one nucleus of this isotope,

(i) the number of protons,

number = ...

(ii) the number of neutrons.

number = ...
[2]

(b) The nucleus of this isotope of iron may be assumed to be a sphere of radius 5.7×10^{-15} m.

Calculate, for one such nucleus,

(i) the mass,

mass = ... kg

(ii) the density.

density = ... kg m^{-3}
[4]

(c) An iron ball is found to have a density of 7900 kg m^{-3}. By reference to your answer in **(b)(ii)**, suggest what can be inferred about the structure of an atom of iron.

.....

.....

..... [2]

6 A nucleus of an atom of francium (Fr) contains 87 protons and 133 neutrons.

(a) Write down the notation for this nuclide.

.....
Fr
..... [2]

(b) The nucleus decays by the emission of an α-particle to become a nucleus of astatine (At).

Write down a nuclear equation to represent this decay. [2]

7 **(a)** Explain what is meant by an *electric field*.

.....

.....[1]

(b) A uniform electric field is produced between two vertical metal plates AB and CD, as shown in Fig. 7.1.

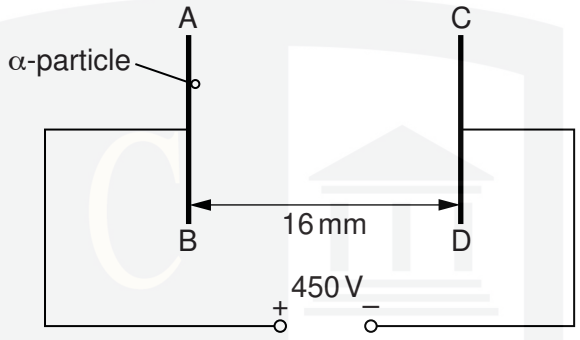

Fig. 7.1

The potential difference between the plates is 450 V and the separation of the plates is 16 mm.

An α-particle is accelerated from plate AB to plate CD.

(i) On Fig. 7.1, draw lines to represent the electric field between the plates. [2]

(ii) Calculate the electric field strength between the plates.

electric field strength = ... $V\,m^{-1}$ [2]

(iii) Calculate the work done by the electric field on the α-particle as it moves from AB to CD.

work done = ... J [3]

(iv) A β-particle moves from AB to CD. Calculate the ratio

$$\frac{\text{work done by the electric field on the } \alpha\text{-particle}}{\text{work done by the electric field on the } \beta\text{-particle.}}$$

Show your working.

ratio = ... [1]

8 **(a)** An electric field is set up between two parallel metal plates in a vacuum. The deflection of α-particles as they pass between the plates is shown in Fig. 7.1.

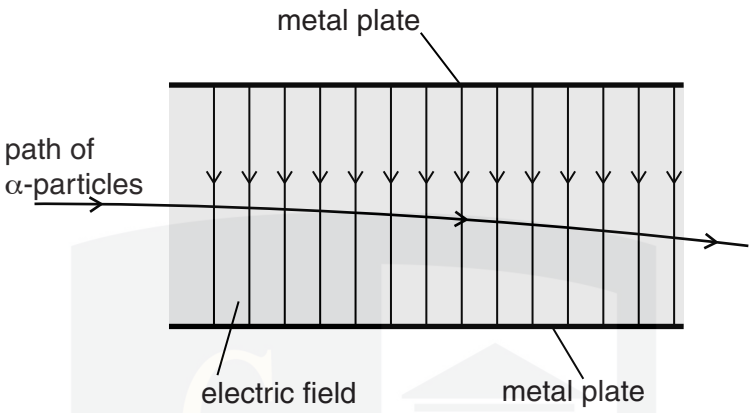

Fig. 7.1

The electric field strength between the plates is reduced. The α-particles are replaced by β-particles. The deflection of β-particles is shown in Fig. 7.2.

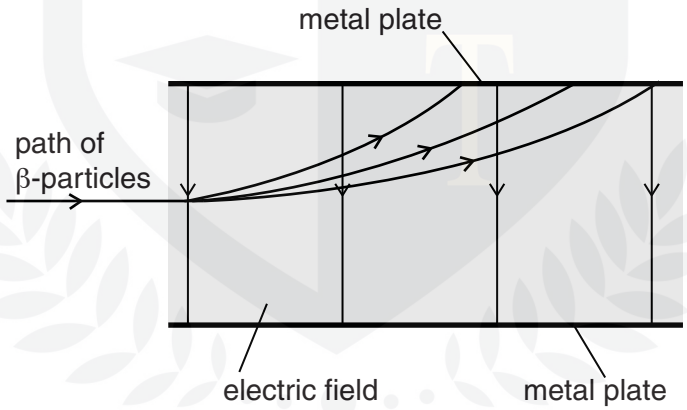

Fig. 7.2

(i) State one similarity of the electric fields shown in Fig. 7.1 and Fig. 7.2.

.....

.....[1]

(ii) The electric field strength in Fig. 7.2 is less than that in Fig. 7.1. State two methods of reducing this electric field strength.

1. .....

2. .....

[2]

(iii) By reference to the properties of α-particles and β-particles, suggest three reasons for the differences in the deflections shown in Fig. 7.1 and Fig. 7.2.

1. .....

.....

2. .....

.....

3. .....

.....

[3]

(b) A source of α-particles is uranium-238. The nuclear reaction for the emission of α-particles is represented by

$$^{238}_{92}\text{U} \rightarrow {}^{W}_{X}\text{Q} + {}^{Y}_{Z}\alpha.$$

State the values of *W*.....

X .....

Y .....

Z .....

[2]

(c) A source of β-particles is phosphorus-32. The nuclear reaction for the emission of β-particles is represented by

$$^{32}_{15}\text{P} \rightarrow {}^{A}_{B}\text{R} + {}^{C}_{D}\beta.$$

State the values of *A* .....

B .....

C .....

D .....

[1]

9 Two horizontal metal plates are separated by distance d in a vacuum. A potential difference V is applied across the plates, as shown in Fig. 6.1.

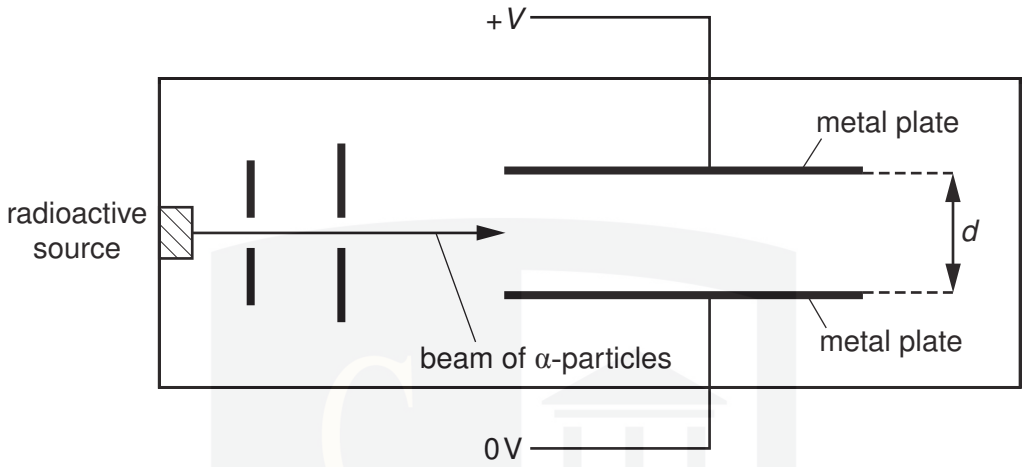

Fig. 6.1

A horizontal beam of α-particles from a radioactive source is made to pass between the plates.

(a) State and explain the effect on the deflection of the α-particles for each of the following changes:

(i) The magnitude of V is increased.

.....

.....[1]

(ii) The separation d of the plates is decreased.

.....

.....[1]

(b) The source of α-particles is replaced with a source of β-particles.
Compare, with a reason in each case, the effect of each of the following properties on the deflections of α- and β-particles in a uniform electric field:

(i) charge

.....

.....

.....[2]

(ii) mass

.....

.....

.....[2]

(iii) speed

.....

.....

.....[1]

(c) The electric field gives rise to an acceleration of the α-particles and the β-particles. Determine the ratio

$$\frac{\text{acceleration of the } \alpha\text{-particles}}{\text{acceleration of the } \beta\text{-particles}}.$$

ratio = ...[3]