Particle Physics

Question paper 2

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Particle & Nuclear Physics
Sub Topic	Particle Physics
Paper Type	Theory
Booklet	Question paper 2

Time Allowed: **78 minutes**

Score: **/65**

Percentage: **/100**

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

1 (a) The spontaneous decay of polonium is shown by the nuclear equation

$$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + X.$$

(i) State the composition of the nucleus of X.

....

.... [1]

(ii) The nuclei X are emitted as radiation. State two properties of this radiation.

1. ....

....

2. ....

....
[2]

(b) The mass of the polonium (Po) nucleus is greater than the combined mass of the nuclei of lead (Pb) and X. Use a conservation law to explain qualitatively how this decay is possible.

....

....

.... [3]

2 A radioactive source emits α-radiation and γ-radiation.

Explain how it may be shown that the source does not emit β-radiation using

(a) the absorption properties of the radiation,

....

....

....

....

.... [2]

(b) the effects of a magnetic field on the radiation.

....

....

....

....

.... [2]

3 **(a)** Two isotopes of the element uranium are $^{235}_{92}U$ and $^{238}_{92}U$.

Explain the term *isotope*.

....

....

.... [2]

(b) **(i)** In a nuclear reaction, proton number and neutron number are conserved. Other than proton number and neutron number, state a quantity that is conserved in a nuclear reaction.

.... [1]

(ii) When a nucleus of uranium-235 absorbs a neutron, the following reaction may take place.

$$^{235}_{92}U + ^{a}_{b}n \longrightarrow ^{141}_{x}Ba + ^{y}_{36}Kr + 3\,^{a}_{b}n$$

State the values of a, b, x and y.

a = ...

b = ...

x = ...

y = ...
[3]

(c) When the nucleus of $^{238}_{92}U$ absorbs a neutron, the nucleus decays, emitting an α-particle. State the proton number and nucleon number of the nucleus that is formed as a result of the emission of the α-particle.

proton number = ...

nucleon number = ...
[2]

4 **(a)** State the experimental observations that show radioactive decay is

(i) spontaneous,

....

.... [1]

(ii) random.

....

.... [1]

(b) On Fig. 7.1, complete the charge and mass of α-particles, β-particles and γ-radiation. Give example speeds of α-particles and γ-radiation emitted by a laboratory source.

	α-particle	β-particle	γ-radiation
charge			0
mass	4u		
speed		up to 0.99*c*	

Fig. 7.1

[3]

(c) Explain the process by which α-particles lose energy when they pass through air.

....

....

.... [2]

5 The results of the α-particle scattering experiment provided evidence for the existence and small size of the nucleus.

(a) State the result that provided evidence for

(i) the small size of the nucleus, compared with the atom,

....

....

.... [2]

(ii) the nucleus being charged and containing the majority of the mass of the atom.

....

....

.... [2]

(b) The α-particles in this experiment originated from the decay of a radioactive nuclide. Suggest two reasons why β-particles from a radioactive source would be inappropriate for this type of scattering experiment.

1. ....

....

2. ....

....

[2]

6 One of the isotopes of uranium is uranium-238 ($^{238}_{92}U$).

(a) State what is meant by *isotopes*.

....

....

.... [2]

(b) For a nucleus of uranium-238, state

(i) the number of protons,

number = ... [1]

(ii) the number of neutrons.

number = ... [1]

(c) A uranium-238 nucleus has a radius of 8.9×10^{-15} m.

Calculate, for a uranium-238 nucleus,

(i) its mass,

mass = ... kg [2]

(ii) its mean density.

density = ... kg m^{-3} [2]

(d) The density of a lump of uranium is $1.9 \times 10^4\,kg\,m^{-3}$.
Using your answer to **(c)(ii)**, suggest what can be inferred about the structure of the atom.

....

....

....[2]

7 **(a)** The radioactive decay of some nuclei gives rise to the emission of α-particles. State

(i) what is meant by an α-particle,

....[1]

(ii) two properties of α-particles.

1. ....

....

2. ....

....
[2]

(b) One possible nuclear reaction involves the bombardment of a stationary nitrogen-14 nucleus by an α-particle to form oxygen-17 and another particle.

(i) Complete the nuclear equation for this reaction.

$$^{14}_{7}\text{N} + \,^{\dots\dots}_{\dots\dots}\alpha \rightarrow \,^{17}_{8}\text{O} + \dots\dots\dots\dots\dots\dots$$ [2]

(ii) The total mass-energy of the nitrogen-14 nucleus and the α-particle is less than that of the particles resulting from the reaction. This mass-energy difference is 1.1 MeV.

1. Suggest how it is possible for mass-energy to be conserved in this reaction.

....

....[1]

2. Calculate the speed of an α-particle having kinetic energy of 1.1 MeV.

speed = ... m s^{-1} [4]

8 One property of α-particles is that they produce a high density of ionisation of air at atmospheric pressure. In this ionisation process, a neutral atom becomes an ion pair. The ion pair is a positively-charged particle and an electron.

(a) State

(i) what is meant by an α-particle,

....

....[1]

(ii) an approximate value for the range of α-particles in air at atmospheric pressure.

range = ... cm [1]

(b) The energy required to produce an ion pair in air at atmospheric pressure is 31 eV.
An α-particle has an initial kinetic energy of 8.5×10^{-13} J.

(i) Show that 8.5×10^{-13} J is equivalent to 5.3 MeV.

[1]

(ii) Calculate, to two significant figures, the number of ion pairs produced as the α-particle is stopped in air at atmospheric pressure.

number = ...[2]

(iii) Using your answer in **(a)(ii)**, estimate the average number of ion pairs produced per unit length of the track of the α-particle as it is brought to rest in air.

number per unit length = ... [2]

9 An α-particle A approaches and passes by a stationary gold nucleus N. The path is illustrated in Fig. 7.1.

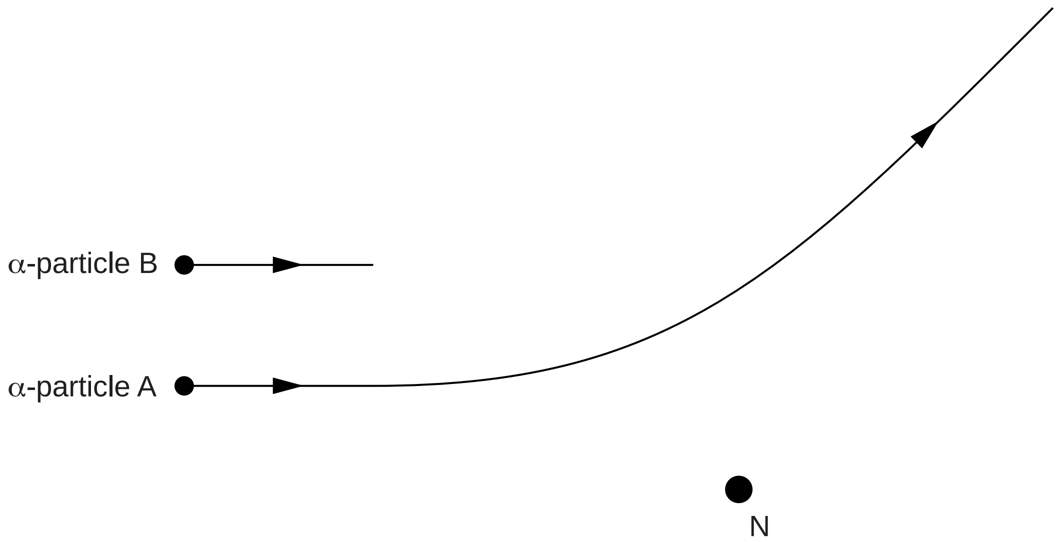

Fig. 7.1

(a) On Fig. 7.1, mark the angle of deviation *D* of this α-particle as a result of passing the nucleus N. [1]

(b) A second α-particle B has the same initial direction and energy as α-particle A.
On Fig. 7.1, complete the path of α-particle B as it approaches and passes by the nucleus N. [2]

(c) State what can be inferred about atoms from the observation that very few α-particles experience large deviations.

....

....

.... [2]

(d) The nucleus N could be one of several different isotopes of gold.

Suggest, with an explanation, whether different isotopes of gold would give rise to different deviations of a particular α-particle.

....

....

.... [2]