Particle Physics

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Particle & Nuclear Physics
Sub Topic	Particle Physics
Paper Type	Theory
Booklet	Question paper 1

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 A uranium-235 nucleus absorbs a neutron and then splits into two nuclei. A possible nuclear reaction is given by

$$^{235}_{92}U + ^{a}_{b}n \rightarrow ^{93}_{37}Rb + ^{c}_{d}X + 2^{a}_{b}n + \text{energy.}$$

(a) State the constituent particles of the uranium-235 nucleus.

..... [1]

(b) Complete Fig. 7.1 for this reaction.

	value
a	
b	
c	
d	

[3]

Fig. 7.1

(c) Suggest a possible form of energy released in this reaction.

..... [1]

(d) Explain, using the law of mass-energy conservation, how energy is released in this reaction.

.....

.....

..... [2]

2 The equation represents the spontaneous radioactive decay of a nucleus of bismuth-212.

$$^{212}_{83}\text{Bi} \rightarrow \text{X} + ^{208}_{81}\text{Tl} + 6.2\,\text{MeV}$$

(a) **(i)** Explain the meaning of ***spontaneous*** radioactive decay.

.....

.....[1]

(ii) State the constituent particles of X.

.....[1]

(b) **(i)** Use the conservation of mass-energy to explain the release of 6.2 MeV of energy in this reaction.

.....

.....

.....[2]

(ii) Calculate the energy, in joules, released in this reaction.

energy = ... J [1]

3 In the decay of a nucleus of $^{210}_{84}Po$, an α-particle is emitted with energy 5.3 MeV.

The emission is represented by the nuclear equation

$$^{210}_{84}Po \rightarrow {}^{A}_{B}X + \alpha + \text{energy}$$

(a) **(i)** On Fig. 7.1, complete the number and name of the particle, or particles, represented by A and B in the nuclear equation.

	number	name of particle or particles
A		
B		

Fig. 7.1

[1]

(ii) State the form of energy given to the α-particle in the decay of $^{210}_{84}Po$.

.....[1]

(b) A sample of polonium $^{210}_{84}Po$ emits 7.1×10^{18} α-particles in one day.

Calculate the mean power output from the energy of the α-particles.

power = ... W [2]

4 **(a)** State what is meant by

α-particle: .....

β-particle: .....

γ-radiation: .....
[2]

(b) Describe the changes to the proton number and the nucleon number of a nucleus when emission occurs of

(i) an α-particle,

.....

..... [1]

(ii) a β-particle,

.....

..... [1]

(iii) γ-radiation.

.....

..... [1]

5 **(a)** Describe the two main results of the α-particle scattering experiment.

result 1: .....

.....

result 2: .....

.....

[3]

(b) Relate each of the results in **(a)** with the conclusions that were made about the nature of atoms.

result 1: .....

.....

result 2: .....

.....

[3]

6 A polonium nucleus $^{210}_{84}Po$ is radioactive and decays with the emission of an α-particle. The nuclear reaction for this decay is given by

$$^{210}_{84}Po \rightarrow {}^{W}_{X}Q + {}^{Y}_{Z}\alpha.$$

(a) **(i)** State the values of ***W*** .....

X .....

Y .....

Z .....

[2]

(ii) Explain why mass seems not to be conserved in the reaction.

.....

.....[2]

(b) The reaction is spontaneous. Explain the meaning of ***spontaneous***.

.....

.....[1]

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

(i) Describe in detail an atom of uranium-235.

.....

.....

.....

.....

..... [4]

(ii) With reference to the two forms of uranium, explain the term ***isotopes***.

.....

.....

..... [2]

(b) When a uranium-235 nucleus absorbs a neutron, the following reaction may occur:

$$^{235}_{92}U + ^{W}_{X}n \rightarrow ^{148}_{57}La + ^{Z}_{Y}Q + 3^{W}_{X}n$$

(i) Determine the values of ***Y*** and ***Z***.

Y = ...

Z = ...

[2]

(ii) Explain why the sum of the masses of the uranium nucleus and of the neutron does not equal the total mass of the products of the reaction.

.....

.....

..... [2]

8 **(a)** Describe the structure of an atom of the nuclide $^{235}_{92}U$.

.....

.....

.....

..... [2]

(b) The deflection of α-particles by a thin metal foil is investigated with the arrangement shown in Fig. 6.1. All the apparatus is enclosed in a vacuum.

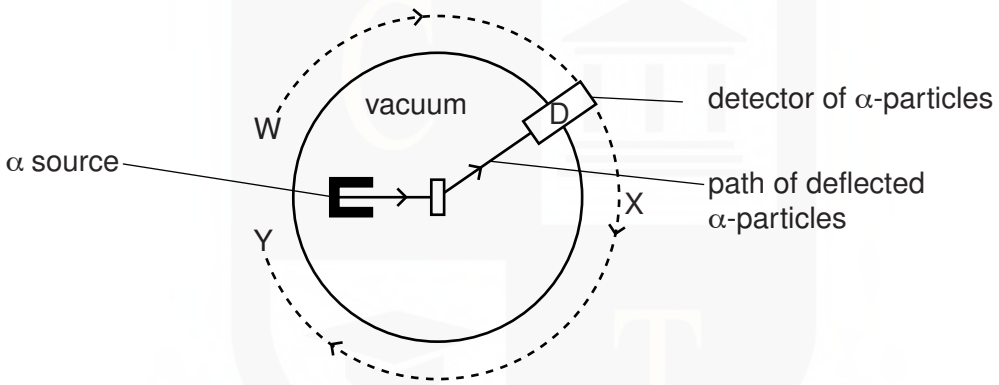

Fig. 6.1

The detector of α-particles, D, is moved around the path labelled WXY.

(i) Explain why the apparatus is enclosed in a vacuum.

.....

..... [1]

(ii) State and explain the readings detected by D when it is moved along WXY.

.....

.....

.....

.....

.....

..... [3]

(c) A beam of α-particles produces a current of 1.5 pA. Calculate the number of α-particles per second passing a point in the beam.

number = ... s^{-1} [3]

9 **(a)** β-radiation is emitted during the spontaneous radioactive decay of an unstable nucleus.

(i) State the nature of a β-particle.

..... [1]

(ii) State two properties of β-radiation.

1. .....

2. .....
[2]

(iii) Explain the meaning of ***spontaneous radioactive decay***.

.....

..... [1]

(b) The following equation represents the decay of a nucleus of hydrogen-3 by the emission of a β-particle.

Complete the equation.

$$^{3}_{1}H \rightarrow \,^{.....}_{.....}He + \,^{.....}_{.....}\beta$$ [2]

(c) The β-particle is emitted with an energy of 5.7×10^{3} eV.

Calculate the speed of the β-particle.

speed = ... $m\,s^{-1}$ [3]

(d) A different isotope of hydrogen is hydrogen-2 (deuterium). Describe the similarities and differences between the atoms of hydrogen-2 and hydrogen-3.

.....

.....

..... [2]