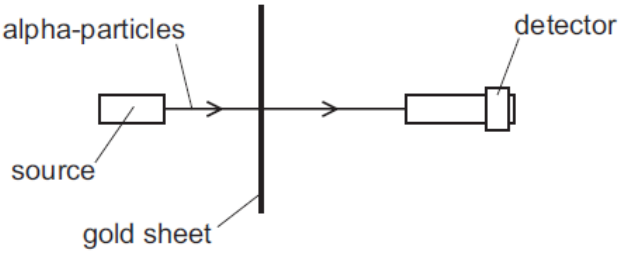
Nuclear physics – 2022 June O Level 5054

1. June/2022/Paper_11/No.40

In the Geiger-Marsden experiment, alpha-particles are fired at a thin gold sheet.



Most alpha-particles pass straight through the thin gold sheet.

A few are deflected.

What can be deduced from this experiment?

A The nucleus is very small.

B The nucleus has no charge.

C Electrons surround the nucleus.

D Electrons have a negative charge.

2. June/2022/Paper_21/No.9

Table 9.1 shows details of seven different nuclides.

Table 9.1

nuclide	radiation emitted	half-life
hydrogen-2	none	–
hydrogen–3	beta	12 year
francium-223	beta	22 min
iridium-192	gamma	74 day
phosphorus-32	beta	14 day
radon−222	alpha	4 day
technetium-99	gamma	6 hour

(a) (i) Hydrogen-2 and hydrogen-3 are isotopes of the element hydrogen.

Define the term isotope.

.....

..... [2]

(ii) The equation for the decay of phosphorus-32 (P-32) as it emits a beta particle is:

$$^{32}_{15}\mathrm{P} \rightarrow {}^{0}_{-1}\beta + {}^{32}_{16}\mathrm{Q}$$

Explain whether the equation shows that Q is another isotope of phosphorus. Q is not the chemical symbol for the atom.

.....

..... [1]

(b) One of the sources in Table 9.1 is used in a medical procedure to detect unusual bone structures. It is injected into a patient and the radiation emitted is detected outside the body.

(i) State which source in Table 9.1 is most suitable for this type of medical use.

..... [1]

(ii) Explain **two** reasons for your choice

.....

.....

..... [2]

(c) Radon gas is one natural source of background radiation.

Some causes of background radiation are man-made, for example, X-rays.

(i) State one other **natural** source of background radiation.

..... [1]

(ii) State one other **man-made** source of background radiation.

..... [1]

(iii) State one **harmful** effect of background radiation.

..... [1]

(d) One fusion reaction that occurs is:

$$^{2}_{1}H + ^{3}_{1}H \rightarrow ^{4}_{2}He + ^{\ldots\ldots}_{\ldots\ldots}X$$

(i) Complete the equation to show the missing proton and nucleon numbers. [1]

(ii) Deduce the name of particle X.

..... [1]

(iii) Suggest where this fusion reaction takes place.

..... [1]

(e) Compare the properties of alpha-particles and beta-particles in terms of their:

- ability to penetrate through materials
- ionising effects
- deflection in a magnetic field.

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..... [3]

[Total: 15]

3. June/2022/Paper_22/No.9

Thorium-229 is a radioactive isotope used in several medical applications that involve alpha-particles and beta-particles.

(a) During ionisation, a helium atom becomes a helium ion.

Fig. 9.1 shows a diagram of a helium (He^+) ion.

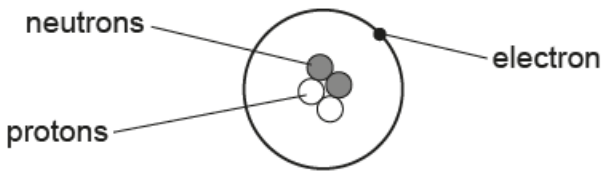

Fig. 9.1

(i) State how the structure of a helium atom differs from the structure of the helium ion.

.....

..... [1]

(ii) State how the structure of an alpha-particle differs from the structure of the helium ion.

.....

..... [1]

(iii) A nucleus of thorium-229 ($^{229}_{90}Th$) decays by alpha (α) emission to a nucleus of element X.

$$^{229}_{90}Th \rightarrow X + {}^{4}_{2}\alpha$$

The nucleus of X then decays to a nucleus of Y by beta (β) emission.

$$X \rightarrow Y + {}^{0}_{-1}\beta$$

Complete Table 9.1 to show the number of protons and neutrons in a nucleus of X and in a nucleus of Y.

Table 9.1

nucleus	number of protons	number of neutrons
X		
Y		

[4]

(b) Experiments can show that a sample of a material is radioactive.

Describe the apparatus and the procedure used to show that a sample emits **both** alpha-particles and beta-particles.

You may draw a diagram of the apparatus, if you wish.

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..... [4]

(c) **(i)** State what is meant by the half-life of thorium-229.

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..... [2]

(ii) A sample of pure thorium-229 contains 4.0×10^{14} atoms. After 22 000 years, the number of atoms of thorium-229 in the sample is 5.0×10^{13}.

Determine the half-life of thorium-229.

Show your working.

half-life = ... [3]

[Total: 15]