# Chapter 5

# Nuclear physics

## 5.1 The nuclear model of the atom

01. 0625_m23_qp_42 Q: 9

**(a)** A nuclear power station has a reactor where controlled nuclear fission of uranium-235 takes place.

**(i)** Explain what is meant by nuclear fission.

.....

.....

.....

.....

..... [3]

**(ii)** State **one** advantage and **one** disadvantage of generating electrical power in nuclear power stations compared with electrical power generated using wind turbines.

advantage .....

disadvantage .....

[2]

**(b)** Deuterium is an isotope of hydrogen (H) with 1 proton and 1 neutron. Nuclear fusion occurs when two nuclei of deuterium combine. An isotope of helium (He) and a neutron are formed.

Use nuclide notation to write down the nuclide equation for this reaction.



[3]

02. 0625_w23_qp_42 Q: 8

The isotope uranium-235 is represented by

$$^{235}_{92}U.$$

**(a)** State what the numbers 92 and 235 represent in this symbol.

92 is .....

235 is .....

[2]

**(b)** Uranium-235 is a fuel used in nuclear reactors.

**(i)** State the process by which energy is released from uranium-235 in a nuclear reactor.

..... [1]

**(ii)** A nuclide equation for this process is

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + 2\ {}^{1}_{0}n.$$

Describe the mass and energy changes that take place during this process in a nuclear reactor.

.....

.....

..... [2]

**(c)** **(i)** Describe how thermal energy from nuclear reactions is used to generate electricity in a power station.

.....

.....

.....

..... [3]

**(ii)** State **one** advantage and **one** disadvantage of using nuclear fuels in a power station instead of using fossil fuels.

advantage .....

.....

disadvantage .....

.....

[2]

03. 0625_s22_qp_41 Q: 10

Two of the isotopes of hydrogen are hydrogen-2 ( $^{2}_{1}H$ ) and hydrogen-3 ( $^{3}_{1}H$ ).

**(a) (i)** State **one** similarity in the composition of their nuclei.

..... [1]

**(ii)** Describe how a nucleus of hydrogen-3 differs from a nucleus of hydrogen-2.

.....

..... [2]

**(b)** In a nuclear fusion reactor, a nucleus of hydrogen-2 fuses with a nucleus of hydrogen-3 at an extremely high temperature. This fusion reaction produces an isotope of element X and releases a neutron.

**(i)** Explain why an extremely high temperature is needed when forcing these two nuclei together.

.....

.....

.....

..... [3]

**(ii)** Using nuclide notation, complete the equation for this reaction.

$^{2}_{1}H + {}^{3}_{1}H \longrightarrow$

[2]

04. 0625_s22_qp_42 Q: 11

**(a)** Fig. 11.1 shows the paths of three $\alpha$-particles moving towards a thin gold foil. Four gold nuclei are shown.

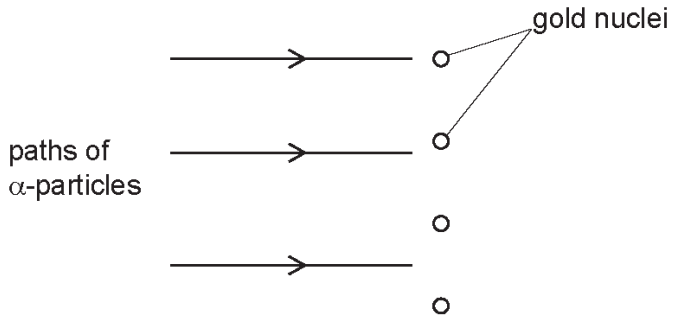


**Fig. 11.1** (not to scale)

**(i)** On Fig. 11.1, complete the paths of the **three** $\alpha$-particles. [3]

**(ii)** State the sign of the charge on the $\alpha$-particles.

..... [1]

**(b)** The nuclide notation for a nucleus of gold-198 is $^{198}_{79}Au$.

State the numbers of electrons, neutrons and protons in a neutral atom of gold-198.

number of electrons = .....

number of neutrons = .....

number of protons = .....

[3]

05. 0625_s21_qp_41 Q: 9

There are three naturally occurring isotopes of hydrogen: hydrogen-1, hydrogen-2 and hydrogen-3.
The nuclide notation for hydrogen-1 is ${}^{1}_{1}\mathrm{H}$.

**(a)** Write down the symbol, using nuclide notation, for:

hydrogen-2 .....

hydrogen-3. .....

[1]

**(b)** In a fusion reactor, a nucleus of hydrogen-2 and a nucleus of hydrogen-3 undergo fusion.

**(i)** State what is meant by *nuclear fusion*.

.....

.....

..... [2]

**(ii)** The fusion reaction produces a free neutron and **one** other particle.

Write down, using nuclide notation, the equation that represents this reaction.

[3]

**(c)** Nuclear fusion in the Sun is the source of most but not all of the resources that are used to generate electrical energy on Earth.

State **two** resources for which nuclear fusion in the Sun is **not** the source.

1. .....

2. .....

[2]

[Total: 8]

06. 0625_w21_qp_42 Q: 11

**(a)** Describe the composition and structure of a neutral atom of beryllium-8, which has a proton number of 4 and a nucleon number of 8.

.....

.....

.....

..... [4]

**(b)** A radioactive isotope decays by β-emission to form an isotope of barium with nucleon number 135.

**Table 11.1**

| element | symbol | proton number |
|---|---|---|
| iodine | I | 53 |
| xenon | Xe | 54 |
| caesium | Cs | 55 |
| barium | Ba | 56 |
| lanthanum | La | 57 |
| cerium | Ce | 58 |
| praseodymium | Pr | 59 |

Use data from Table 11.1 to write down the nuclide equation for this decay.



[4]

07. 0625_w20_qp_43 Q: 11

**(a)** Fig. 11.1 shows a beam of $\alpha$-particles, $\beta$-particles and $\gamma$-rays directed between two metal plates P and Q.

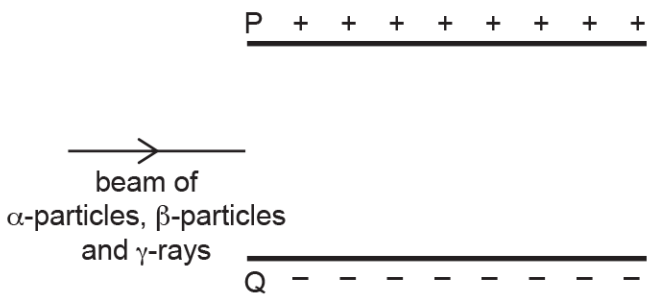


**Fig. 11.1**

The metal plates are parallel and there is a large potential difference (p.d.) between them. Plate P is positive and plate Q is negative.

On Fig. 11.1, draw the paths of each of the radiations between the plates and after leaving the plates.

Label the paths $\alpha$, $\beta$ and $\gamma$. [5]

**(b)** State and explain **one** practical application of $\gamma$-rays.

application .....

explanation .....

..... [2]

08. 0625_s19_qp_41 Q: 9

**(a)** Fig. 9.1 shows a beam of $\alpha$-particles moving towards a thin sheet of gold in a vacuum.

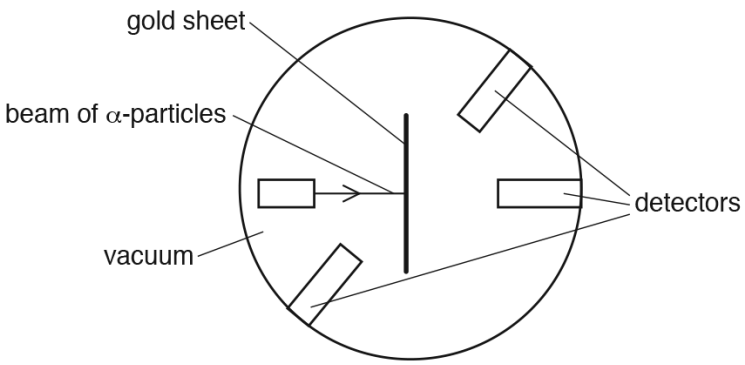


**Fig. 9.1**

Detectors in the region surrounding the thin gold sheet detect the $\alpha$-particles and determine the number of particles that travel in various directions.

State and explain what can be deduced from the following observations.

**(i)** The majority of the $\alpha$-particles pass through the gold sheet undeflected and are detected on the far side.

deduction .....

explanation .....

..... [2]

**(ii)** A small number of $\alpha$-particles are deflected as they pass through the gold sheet.

deduction .....

explanation .....

..... [2]

**(iii)** A very small number of $\alpha$-particles are deflected through very large angles or return back the way they came.

deduction .....

explanation .....

..... [2]

**(b)** A beam that consists of both $\alpha$-particles and $\beta$-particles is passed through a region of space where there is a magnetic field perpendicular to the direction of the beam.

State **two** ways in which the deflection of the $\alpha$-particles differs from that of the $\beta$-particles.

1. .....

2. .....

[2]

[Total: 8]

---