5. Nuclear physics

5.1 The nuclear model of the atom

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 A nucleus of strontium-90 is represented using nuclide notation as shown.

$$^{90}_{38}\text{Sr}$$

(a) (i) Calculate the number of neutrons in one nucleus of strontium-90.

number of neutrons = ... [2]

(ii) Determine the number of electrons in one atom of strontium-90.

number of electrons = ... [1]

2 A nucleus of an isotope of actinium contains 89 protons and 136 neutrons.
The chemical symbol for actinium is Ac.

(a) (i) Complete the nuclide notation for this isotope of actinium.

$$^{\cdots\cdots}_{\cdots\cdots}\text{Ac}$$

[1]

(ii) State the number of electrons orbiting the nucleus of a neutral atom of this isotope.

number of electrons = ... [1]

3 Fig. 11.1 represents all the particles in a beryllium atom.

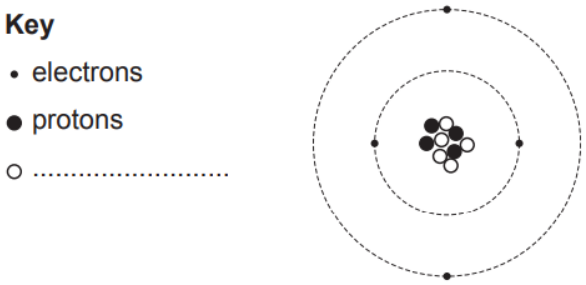

Fig. 11.1 (not to scale)

(a) (i) The symbol for the element beryllium is Be. Give the nuclide notation for the isotope shown in Fig. 11.1.

..... Be
.....

[1]

(ii) The key for Fig. 11.1 gives the names of two types of particle. One label is missing.

Complete the key by adding the name of the third type of particle shown in Fig. 11.1. [1]

4 Iodine-131 is a radioactive isotope of the element iodine. Fig. 10.1 shows the nuclide notation for a nucleus of iodine-131.

$$^{131}_{53}\mathrm{I}$$

Fig. 10.1

(a) (i) Determine the number of protons in one nucleus of iodine-131.

number of protons = ... [1]

(ii) Determine the number of neutrons in one nucleus of iodine-131.

number of neutrons = ... [1]

5 Fig. 11.1 represents an atom of carbon-14.

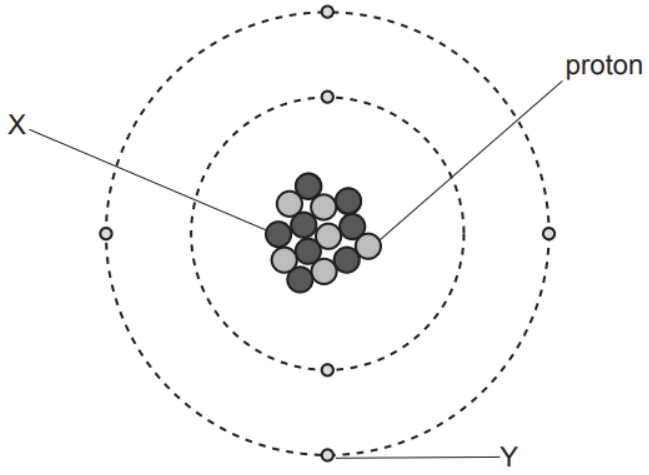

Fig. 11.1

(a) (i) State the name of the particle labelled X.

..... [1]

(ii) State the name of the particle labelled Y.

..... [1]

(iii) State the nucleon number of carbon-14.

..... [1]

6 **(a)** The nuclide notation ${}^{A}_{Z}X$ describes the nucleus of an atom.

Draw a line from each symbol to the correct description of the symbol.

symbol	**description**
	half-life value
A	neutron number
	nucleon number
Z	type of radiation
	proton number

[2]

7 **(a)** Fig. 11.1 represents the particles in a neutral lithium atom.

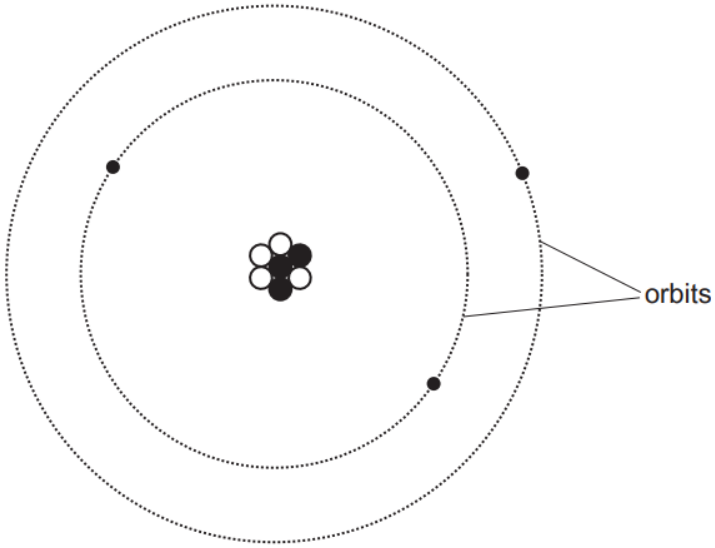

Fig. 11.1

Use the information in Fig. 11.1 about the lithium atom to answer **(a)(i)**, **(a)(ii)** and **(a)(iii)**.

(i) Determine the number of electrons. ..... [1]

(ii) Determine the value of the nucleon number. ..... [1]

(iii) Determine the number of neutrons. ..... [1]

8 **(a)** Carbon-14 is a radioactive isotope of carbon. An atom of carbon-14 has 6 protons in its nucleus.

Another isotope of carbon is carbon-12.

(i) Determine the number of protons in a carbon-12 nucleus.

..... [1]

(ii) Determine the number of neutrons in a carbon-14 nucleus.

..... [1]

(iii) Determine the number of electrons orbiting the nucleus of a single carbon-14 atom.

..... [1]

9 **(a)** Use words from the box to complete the sentences about the charges in an atom. Words can be used once, more than once or not at all.

negative	neutral	positive

The charge on the nucleus of an atom is .....

The charge on a proton is .....

The charge on electrons orbiting the nucleus is .....

[3]

(b) A nucleus of radium-226 has the nuclide notation shown.

$$^{226}_{88}\mathrm{Ra}$$

(i) Determine the number of protons in a nucleus of radium-226.

..... [1]

(ii) Determine the number of neutrons in a nucleus of radium-226.

..... [1]

(iii) Radium has another isotope, radium-223.

Write the nuclide notation for radium-223 in the space.

[1]

(c) Radium-226 has a half-life of 1600 years.

A sample contains 8.0 mg of radium-226.

Calculate the time for the sample to decay until only 1.0 mg of radium-226 remains.

time = ... years [2]

[Total: 8]

10 This notation represents the nucleus of a neutral atom of carbon-14.

$$^{14}_{6}C$$

(a) State the number of:

1. protons in the nucleus of an atom of carbon-14

.....[1]

2. electrons orbiting the nucleus of an atom of carbon-14

.....[1]

3. neutrons in the nucleus of an atom of carbon-14.

.....[1]

11 **(a)** Draw a line from each part of the atom to its description.

part of the atom	description
nucleus	is an electromagnetic wave
electron	is the centre of the atom
neutron	has no electric charge
	orbits the centre of an atom

[3]

12 **(a)** The nuclide notation ${}^{A}_{Z}X$ describes the nucleus of one type of atom.

Draw a line from each symbol to the correct description for that symbol.

symbol	**description**
A	number of neutrons
	element symbol
Z	proton number
	nucleon number
X	number of atoms

[3]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

13 The nuclide notation for the radioactive isotope carbon-14 is $^{14}_{6}C$.

(a) Using the symbols shown in Fig. 8.1, draw a diagram to show the number of electrons, neutrons and protons in a neutral atom of carbon-14 and how they are arranged.

symbols:

electron ×

neutron ○

proton ●

Fig. 8.1

[3]

(b) Describe how the composition of a neutral atom of carbon-14 is different from the composition of a neutral atom of nitrogen-14 ($^{14}_{7}N$).

.....

..... [2]

14 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. **(extended only)**

..... [1]

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

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

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]

[Total: 10]

15 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. **(extended only)**

....

....

....

.... [3]

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

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

[2]

[Total: 8]

16 Uranium-235 ($^{235}_{92}U$) is a radioactive isotope of uranium that occurs naturally on Earth.

(a) Describe the composition and structure of a neutral atom of uranium-235.

.....

.....

.....

.....

..... [4]

(b) Another isotope of uranium is uranium-238.

Describe how an atom of uranium-238 differs from an atom of uranium-235.

.....

..... [1]

(c) In the reactor in a nuclear power station, a nucleus of uranium-235 absorbs a slow-moving neutron and then undergoes nuclear fission. **(extended only)**

Two neutrons, a nucleus of xenon-140 ($^{140}_{54}Xe$) and a nucleus of an element represented by E are produced.

Complete the equation for this fission reaction.

$$n + {}^{235}_{92}U \rightarrow {}^{140}_{54}Xe + {}^{\cdots\cdots}_{\cdots\cdots}E + 2n$$

[2]

17 **(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]

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

(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*. **(extended only)**

.....

.....

..... [2]

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

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. **(extended only)**

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

1. .....

2. .....

[2]

[Total: 8]

19 **(a)** State **two** differences between nuclear fission and nuclear fusion. **(extended only)**

1 .....

.....

2 .....

.....

[2]