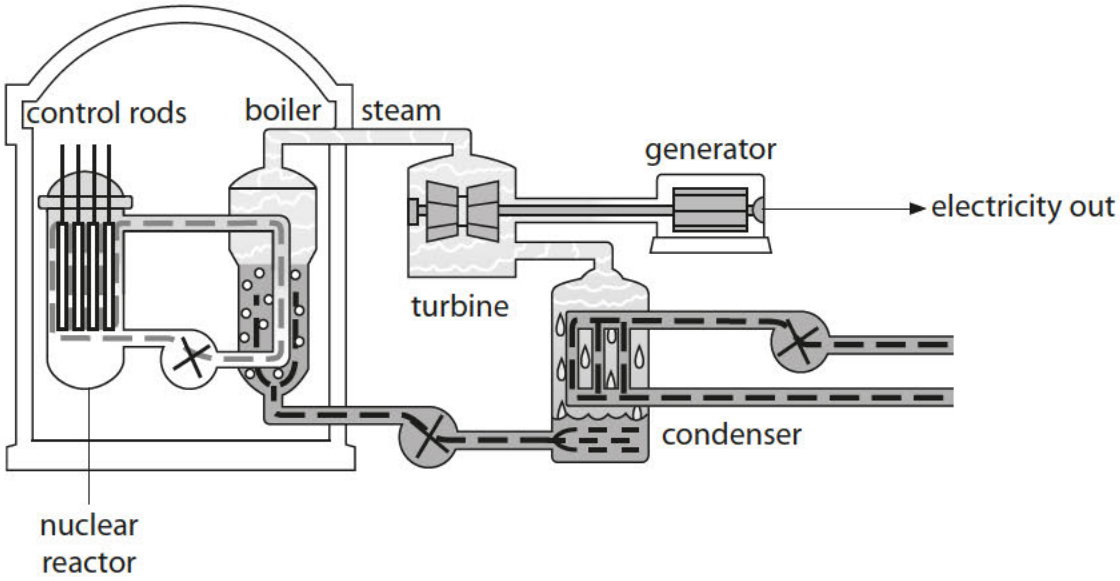
Nuclear fission and radiation

1 The diagram shows parts of a nuclear power station.



(a) (i) Which part of the power station provides thermal (heat) energy from a chain reaction?

Put a cross (☒) in the box next to your answer.

(1)

- ☐ **A** nuclear reactor
- ☐ **B** turbine
- ☐ **C** generator
- ☐ **D** condenser

(ii) Which part of the power station transfers kinetic energy into electrical energy?

Put a cross (☒) in the box next to your answer.

(1)

- ☐ **A** nuclear reactor
- ☐ **B** boiler
- ☐ **C** turbine
- ☐ **D** generator

(b) An isotope of krypton, krypton-89, is produced in the nuclear reactor.
A nucleus of this isotope can be represented as

$$^{89}_{36}Kr$$

Describe the structure of a nucleus of krypton-89.

(4)

(c) Use words from the box to complete the following sentence.

The words may be used once, more than once, or not at all.

(2)

alpha	atom	beta
molecule	neutron	nucleus

During nuclear fission, a uranium-235 ..... splits

when it absorbs a slow moving .....

(d) There are many control rods in a nuclear reactor.

Explain how control rods are used to reduce the number of nuclear reactions in the reactor.

(2)

(Total for Question 3 = 10 marks)

2 (a) The nucleus of a hydrogen atom can be represented by this symbol:

$$^{1}_{1}H$$

(i) Complete this sentence by putting a cross (☒) in the box next to your answer.

The symbol shows that the nucleus consists of

(1)

- ☐ **A** 1 proton and 1 neutron
- ☐ **B** 1 proton only
- ☐ **C** 1 neutron only
- ☐ **D** 1 neutron and 1 electron.

(ii) Two other isotopes of hydrogen are deuterium (D) and tritium (T).

Their nuclei can be represented by these symbols:

$$^{2}_{1}D \qquad\qquad ^{3}_{1}T$$

State how these symbols show that they are isotopes of hydrogen.

(1)

.....

.....

(b) Nuclear fusion can occur if a deuterium and a tritium nucleus can be brought close enough to each other.

This fusion produces a helium nucleus and releases a neutron.

(i) Compare the charges of a helium nucleus and a neutron.

(2)

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(ii) Nuclear fusion is an important process.
Scientists have said '*without nuclear fusion, there would be no life on Earth*'.

Explain why nuclear fusion is important to life on Earth.

(2)

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*(c) Neutrons are also released during nuclear fission.
Describe how the neutrons released in nuclear fission are used to produce a controlled chain reaction in a nuclear reactor.

(6)

(Total for Question 6 = 12 marks)

Nuclear reactors

3 (a) Fast neutrons are released during nuclear fission.

(i) Three different components of a nuclear fission reactor are shown.
Three different materials used in a nuclear fission reactor are also shown.

Draw one line from each component to the material it contains.

(2)

Component	**M terial**
fuel	boron (absorbs neutrons)
control rod	uranium (releases neutrons)
moderator	graphite (slows neutrons)

(ii) Another type of nuclear reactor is a fusion reactor.
Nuclear fusion also releases fast neutrons.

Suggest why a nuclear fusion reactor does not need anything to slow these neutrons down.

(1)

.....

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(b) Both nuclear fissi

Describe how the thermal energy released could be converted into electrical energy in a power station.

(3)

*(c) Scientists and engineers are still trying to build a practical and economic nuclear fusion reactor.

They have not been able to sustain the extreme conditions needed for controlled nuclear fusion.

Explain what these conditions are and why they are needed.

(6)

(Total for Question 5 = 12 marks)

Double alpha emission

4 Beryllium-9 is a stable isotope of beryllium.

(a) (i) State the meaning of the term **stable**.

(1)

.....

.....

(ii) Beryllium-9 has an atomic number of 4 and a mass number of 9.
A nucleus of this isotope can be described using this symbol.

$$^{9}_{4}\mathrm{Be}$$

Complete the sentence by putting a cross (☒) in the box next to your answer.

The number of neutrons in this nucleus is

(1)

☐ **A** 4

☐ **B** 5

☐ **C** 9

☐ **D** 13

(iii) Which one of these symbols describes the nucleus of a different isotope of beryllium?

Put a cross (☒) in the box next to your answer.

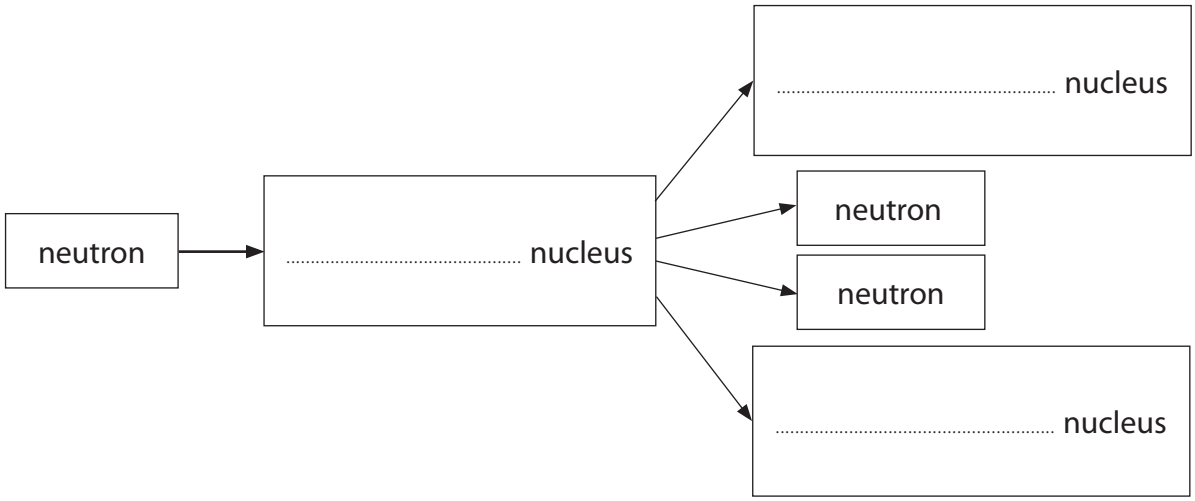
(1)

$^{8}_{4}\mathrm{Be}$	$^{8}_{5}\mathrm{Be}$	$^{9}_{4}\mathrm{B}$	$^{9}_{5}\mathrm{Be}$
☐ **A**	☐ **B**	☐ **C**	☐ **D**

(b) A beryllium-9 nucleus absorbs a neutron.
After a short time the new nucleus splits into two neutrons and two alpha particles.

(i) Complete the flow chart for this reaction.

(2)



(ii) Compare this nuclear reaction with the fission of a uranium nucleus.

(3)

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(iii) A fission reaction can be the start of a chain reaction.

Describe what needs to happen next to produce a chain reaction.

(2)

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(Total for Question 4 = 10 marks)