GCSE Physics

Nuclear Fission and Fusion

Question Paper

Time available: 60 minutes
Marks available: 53 marks

1. Nuclear fission and nuclear fusion are two processes that release energy.

(a) The following nuclear equation represents the fission of uranium-235 (U-235).

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + \text{energy} $$

Chemical symbols:

- Ba = barium
- Kr = krypton
- ${}^{1}_{0}n$ = neutron

Describe the process of nuclear fission.

Use the information in the equation.

(4)

(b) Explain what happens in the process of nuclear fusion.

(3)

(c) Fission reactors are used in nuclear power stations.

Engineers are developing fusion reactors for use in power stations.

Fusion uses isotopes of hydrogen called deuterium and tritium.

- Deuterium is naturally occurring and can be easily extracted from seawater.
- Tritium can be produced from lithium. Lithium is also found in seawater.

The table shows the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	**Energy released from 1 kg of fuel in joules**
Fusion	3.4×10^{14}
Fission	8.8×10^{13}

Suggest **two** advantages of the fuel used in a fusion reactor compared with the fuel used in a fission reactor.

1. _____

_____

_____

2. _____

_____

_____

(2)

(Total 9 marks)

2. (a) Uranium has two natural isotopes, uranium-235 and uranium-238.

Use the correct answer from the box to complete the sentence.

electrons	**neutrons**	**protons**

The nucleus of a uranium-238 atom has three more _____ than the nucleus of a uranium-235 atom.

(1)

(b) Uranium-235 is used as a fuel inside a nuclear reactor.
Energy is released from nuclear fuels by the process of nuclear fission.

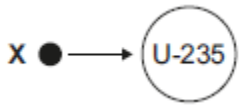
What is the energy released from nuclear fuels inside a nuclear reactor used for?

_____

(1)

(c) **Figure 1** shows the nucleus of an atom of uranium-235 (U-235) about to undergo nuclear fission.

Figure 1



(i) Before nuclear fission can happen the nucleus of a uranium atom has to absorb the particle labelled **X**.

What is particle **X**?

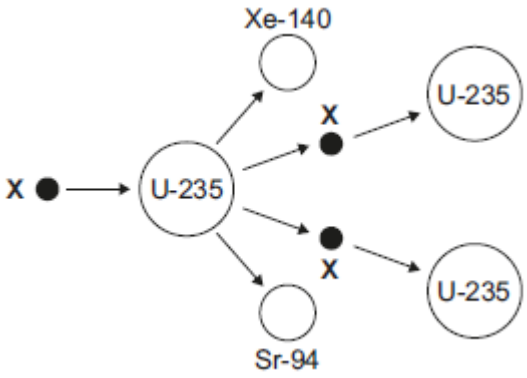
Tick (✓) **one** box.

an electron ☐ a neutron ☐ a proton ☐

(1)

(ii) The process of nuclear fission, shown in **Figure 2**, causes the nucleus of the uranium-235 (U-235) atom to split apart and release two of the particles X.

Figure 2



Complete **Figure 2** to show how the particles **X start** a chain reaction.

(2)

(Total 5 marks)

3. The equation below shows the process by which two atomic nuclei join to form a different nucleus.

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

(a) Where does the process shown by the equation above happen naturally?

Tick (✓) **one** box.

Inside the Earth ☐

Inside a nuclear power station ☐

Inside the Sun ☐

(1)

(b) Use the correct answer from the box to complete the sentence.

fission	**force**	**fusion**

The process of joining two atomic nuclei to form a different nucleus is called

nuclear _____ .

(1)

(c) What is released during this process?

Draw a ring around the correct answer.

charge **energy** **force**

(1)

(Total 3 marks)

4. Many countries use nuclear power stations to generate electricity.
Nuclear power stations use the process of nuclear fission to release energy.

(a) (i) What is nuclear fission?

_____

_____

(1)

Plutonium-239 is one substance used as a fuel in a nuclear reactor. For nuclear fission to happen, the nucleus must absorb a particle.

What type of particle must be absorbed?

_____

(1)

(b) Nuclear **fusion** also releases energy.
Nuclear fusion happens at very high temperatures. A high temperature is needed to overcome the repulsion force between the nuclei.

(i) Why is there a repulsion force between the nuclei of atoms?

_____

_____

(1)

(ii) Where does nuclear fusion happen naturally?

_____

(1)

(c) In 1991, scientists produced the first controlled release of energy from an experimental nuclear **fusion** reactor. This was achieved by fusing the hydrogen isotopes, deuterium and tritium.

Deuterium is naturally occurring and can easily be extracted from seawater. Tritium can be produced from lithium. Lithium is also found in seawater.

The table gives the energy released from 1 kg of fusion fuel and from 1 kg of fission fuel.

Type of fuel	**Energy released from 1 kg of fuel in joules**
Fusion fuel	3.4×10^{14}
Fission fuel	8.8×10^{13}

(i) Suggest **two** advantages of the fuel used in a fusion reactor compared with plutonium and the other substances used as fuel in a fission reactor.

1. _____

_____

_____

2. _____

_____

_____

(2)

(ii) Some scientists think that by the year 2050 a nuclear fusion power station capable of generating electricity on a large scale will have been developed.

Suggest **one** important consequence of developing nuclear fusion power stations to generate electricity.

_____

_____

_____

(1)

(d) Tritium is radioactive.

After 36 years, only 10 g of tritium remains from an original sample of 80 g.

Calculate the half-life of tritium.

Show clearly how you work out your answer.

_____

_____

Half-life = _____ years

(2)

(Total 9 marks)

5. (a) Nuclear power stations generate about 14% of the world's electricity.

(i) Uranium-235 is used as a fuel in some nuclear reactors.

Name **one** other substance used as a fuel in some nuclear reactors.

_____

(1)

(ii) Energy is released from nuclear fuels by the process of nuclear fission.

This energy is used to generate electricity.

Describe how this energy is used to generate electricity.

Do **not** explain the nuclear fission process.

_____

_____

_____

_____

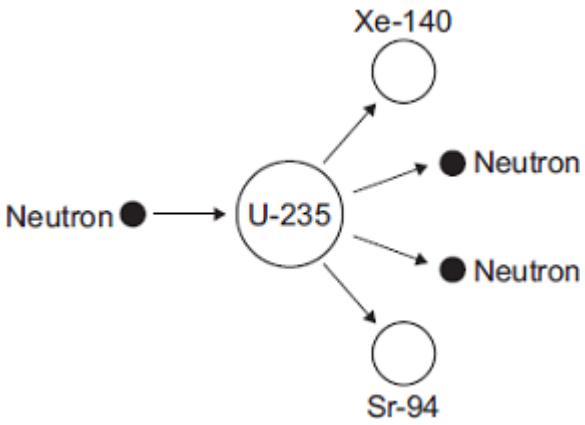
_____

_____

(3)

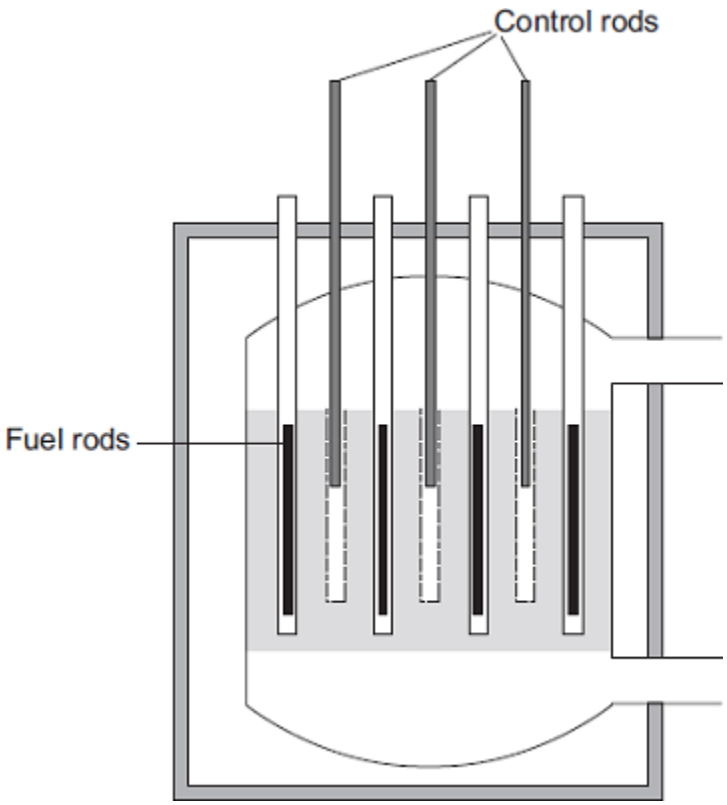
(b) The diagram shows the nuclear fission process for an atom of uranium-235.

Complete the diagram to show how the fission process starts a chain reaction.



(2)

(c) The diagram shows the cross-section through a nuclear reactor.



The control rods, made from boron, are used to control the chain reaction. Boron atoms absorb neutrons without undergoing nuclear fission.

Why does lowering the control rods reduce the amount of energy released each second from the nuclear fuel?

_____

_____

_____

_____

(2)

(Total 8 marks)

6. (a) Nuclear fission is used in nuclear power stations to generate electricity. Nuclear fusion happens naturally in stars.

(i) Explain briefly the difference between *nuclear fission* and *nuclear fusion*.

_____

_____

_____

_____

_____

(2)

(ii) What is released during both nuclear fission and nuclear fusion?

_____

(1)

(b) Plutonium-239 is used as a fuel in some nuclear reactors.

(i) Name another substance used as a fuel in some nuclear reactors.

_____

(1)

(ii) There are many isotopes of plutonium.

What do the nuclei of different plutonium isotopes have in common?

_____

(1)

(Total 5 marks)

7. The names of three different processes are given in **List A**.
Where these processes happen is given in **List B**.

Draw a line to link each process in **List A** to where the process happens in **List B**.

Draw only **three** lines.

List A	**List B**
Process	**Where it happens**
fusion	in a star
chain reaction	in a nuclear reactor
alpha decay	in a smoke precipitator
	in the nucleus of an atom

(Total 3 marks)

8. The process of nuclear fusion results in the release of energy.

(a) (i) Describe the process of nuclear fusion.

_____

_____

_____

_____

(2)

(ii) Where does nuclear fusion happen naturally?

_____

(1)

(b) For many years, scientists have tried to produce a controlled nuclear fusion reaction that lasts long enough to be useful. However, the experimental fusion reactors use more energy than they produce.

(i) From the information given, suggest **one** reason why nuclear fusion reactors are not used to produce energy in a nuclear power station.

_____

_____

(1)

(ii) Suggest **one** reason why scientists continue to try to develop a practical nuclear fusion reactor.

_____

_____

(1)

(Total 5 marks)

9. (a) Uranium atoms do not always have the same number of neutrons.
What are atoms of the same element that have different numbers of neutrons called?

_____

(1)

(b) By emitting an alpha particle, an atom of uranium-235 decays into an atom of thorium.

An alpha particle, which is the same as a helium nucleus, is represented by the symbol $^{4}_{2}He$.

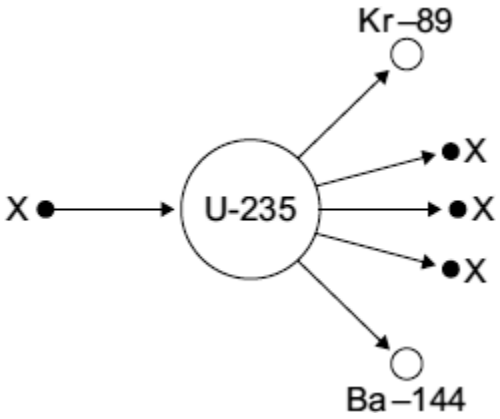
The decay can be represented by the equation below.

Complete the equation by writing the correct number in each of the two boxes.

$$^{235}_{92}U \longrightarrow \square \; Th \; + \; ^{4}_{2}He$$

(2)

(c) The diagram shows an atom of uranium-235 being split into several pieces.



(i) Name the process shown in the diagram.

_____

(1)

(ii) Name the particles labelled **X**.

_____

(1)

(d) Uranium-235 is used as a fuel in some nuclear reactors.
Name another substance used as a fuel in some nuclear reactors.

_____

(1)

(Total 6 marks)