WJEC Physics GCSE
Topic 2.9: Nuclear decay and nuclear energy
Questions by topic

1.

Complete the following paragraph about a nuclear reactor by **underlining** the correct word or words in each of the brackets. [5]

The absorption of **(slow protons / slow neutrons / slow electrons)** can cause a **(fusion / fission / chemical)** reaction in uranium nuclei. The particles are slowed down by **(a moderator / control rods / concrete shielding)**. The emission of **(protons / neutrons / electrons)** in this reaction can cause a chain reaction. An uncontrolled chain reaction is prevented by using **(a moderator / control rods / concrete shielding)**.

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2.

In 1986, a catastrophic event occurred in a nuclear reactor in Chernobyl in Russia that caused the reactor to explode, sending radioactive material into the atmosphere, causing nuclear fallout around the world.
Describe what happens in a fission reactor to enable a controlled chain reaction to occur and how uncontrolled reactions such as those that occurred in Chernobyl are prevented. [6 QWC]

3.

Energy can be released in nuclear fission and nuclear fusion reactions.

(i) Explain how a sustainable, controlled chain reaction is achieved in a nuclear fission reactor containing uranium fuel rods, a moderator and control rods. [4]

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(ii) Explain why controlled nuclear fusion reactions are difficult to achieve on Earth. [2]

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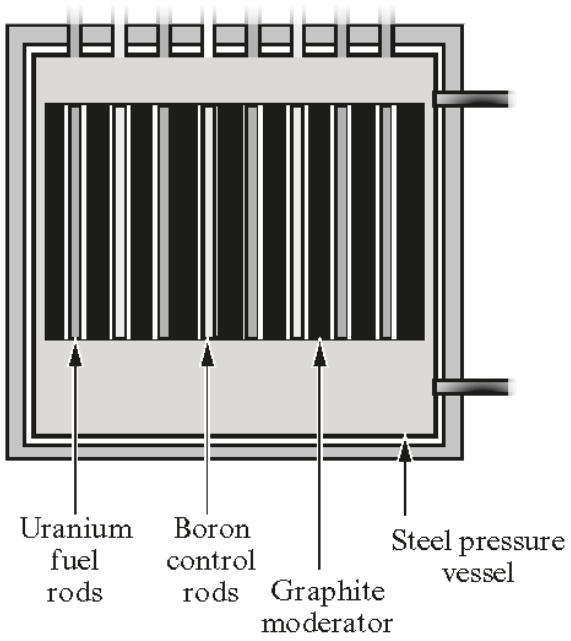
4.

The diagram shows a nuclear fission reactor.



(a) (i) State which labelled part of the reactor slows down neutrons. [1]

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(ii) Give a reason why the neutrons need to be slowed down. [1]

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(b) (i) State which labelled part of the reactor absorbs neutrons. [1]

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(ii) Give a reason why neutrons need to be absorbed. [1]

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(c) The reaction in this type of reactor is shown below.

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \longrightarrow {}^{142}_{56}\text{Ba} + {}^{91}_{36}\text{Kr} + 3{}^{1}_{0}\text{n}$$

Use the information in the equation to answer the questions below.

(i) State the nucleon number of uranium (U). ..... [1]

(ii) State the proton number of krypton (Kr). ..... [1]

(iii) Calculate the number of neutrons in an atom of krypton. .....[1]

(d) One of the products, barium (Ba), has other isotopes.
Circle the correct symbol of an isotope of barium in the following list. [1]

$^{142}_{57}\text{Ba}$ $^{136}_{56}\text{Ba}$ $^{136}_{51}\text{Ba}$

(e) The other product krypton, decays into rubidium (Rb) by emitting beta particles.
Complete the decay equation shown below. [2]

$$^{91}_{36}\text{Kr} \longrightarrow {}^{\ldots\ldots}_{\ldots\ldots}\text{Rb} + {}^{\ldots\ldots}_{-1}\text{e}$$

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5.

The table below gives information about some elements.

Element	Symbol	Nucleon number (A)	Proton number (Z)	Number of neutrons in a nucleus
Hydrogen	H	1	1	0
Helium	He	4	2	.....
Iron	Fe	.....	26	30
Lead	Pb	207	82	125
Krypton	Kr	90	36	54
Barium	Ba	144	56	88
Uranium	U	235	92	143

(a) **Complete** the table. [2]

(b) Tritium has a proton number of 1 and a nucleon number of 3.
Tritium is an isotope of one of the elements in the table above. Which one? [1]

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(c) The **nuclear** symbol for uranium is written as $^{235}_{92}U$.
Use information in the table above to answer the following questions.

(i) Complete the nuclear symbol for lead. $^{\cdots\cdots}_{\cdots\cdots}Pb$ [1]

(ii) In a nuclear reactor, uranium undergoes fission by absorbing a neutron ($^{1}_{0}n$).
The products of this reaction are **krypton**, **barium** and **two neutrons**.

Complete the equation below for this reaction. [2]

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow \cdots\cdots + \cdots\cdots + \cdots\cdots {}^{1}_{0}n$$

(d) Complete the sentences below by **underlining** the correct word(s) in the brackets. [2]

(i) In a nuclear reactor the moderator (**slows down / speeds up / absorbs**) neutrons.

(ii) In a nuclear reactor the control rods (**slow down / speed up / absorb**) neutrons.

8

6.

Nuclear fission and nuclear fusion are examples of nuclear reactions. Typical nuclear fission and nuclear fusion reactions are shown below.

(a) (i) Complete the equation for the first reaction. [2]

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{n} \rightarrow {}^{90}_{\ldots\ldots}\mathrm{Sr} + {}^{144}_{54}\mathrm{Xe} + \ldots\ldots\ {}^{1}_{0}\mathrm{n}$$

$$^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$$

(ii) Explain how the first reaction could lead to an uncontrolled chain reaction. [2]

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(b) $^{2}_{1}\mathrm{H}$ and $^{3}_{1}\mathrm{H}$ are both isotopes of hydrogen.

Compare the structure of the **nuclei** of these two isotopes. [2]

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(c) Nuclear fission and nuclear fusion both produce heat energy. Describe and compare nuclear fission and nuclear fusion reactions. [6 QWC]

Include in your answer:

- what happens in each of the reactions;
- the problems associated with each reaction.

(You are **not** required to include any detail on moderators or control rods.)

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7.

The following equation shows a nuclear reaction.

REACTANTS			PRODUCTS		
$^{2}_{1}\mathrm{H}$	+	$^{3}_{1}\mathrm{H}$	$\rightarrow$ $^{4}_{2}\mathrm{He}$	+	$^{1}_{0}\mathrm{n}$

(a) The reactants have to move very quickly for this reaction to take place and controlling this reaction on Earth is difficult. **Complete** the following sentences. [2]

(i) The reactants are made to collide with high energies by making the gas

.....

(ii) The problem this causes is .....

.....

(b) Underline the correct word in the brackets in each sentence below. [3]

(i) The reactants are isotopes of (**hydrogen / helium / neutrons**).

(ii) The reactants have the same numbers of (**neutrons / protons / nucleons**).

(iii) This reaction is an example of a (**fusion / fission / chain**) reaction.

(c) Give **two** reasons why this reaction is likely to be important in the future. [2]

I. .....

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II. .....

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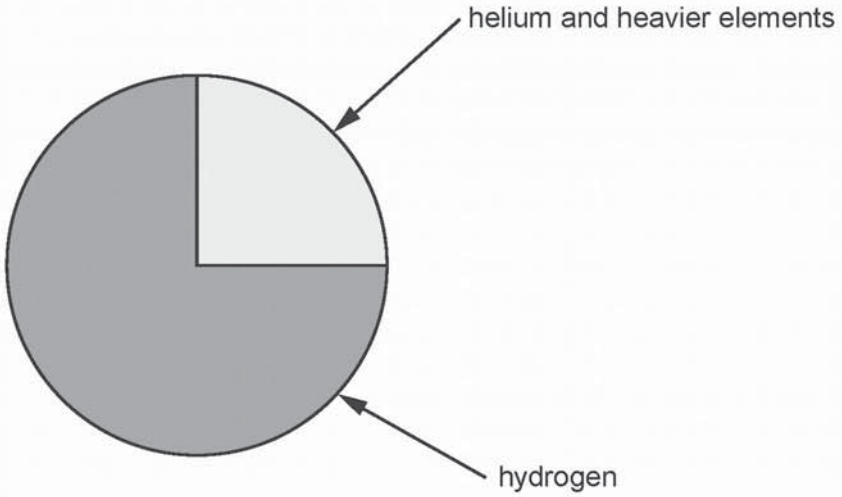
8.

The substances in the early Universe are shown in the following pie chart.
The chart is drawn to scale.



(a) What percentage of the Universe was hydrogen? [1]

..... %

(b) The Big Bang theory suggests that helium was formed from hydrogen in the following way.

$$4\,{}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + 2\,{}^{0}_{1}\mathrm{e}$$

(i) State the number of hydrogen nuclei in this reaction. [1]

.....

(ii) State the number of protons involved in this reaction. [1]

.....

(iii) State the name of the particle ${}^{0}_{1}\mathrm{e}$. [1]

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(c) (i) Main sequence stars generate their energy in the reaction shown above. State the names of the two forces that are balanced in main sequence stars. [2]

..... and .....

(ii) State why our Sun will never produce uranium. [1]

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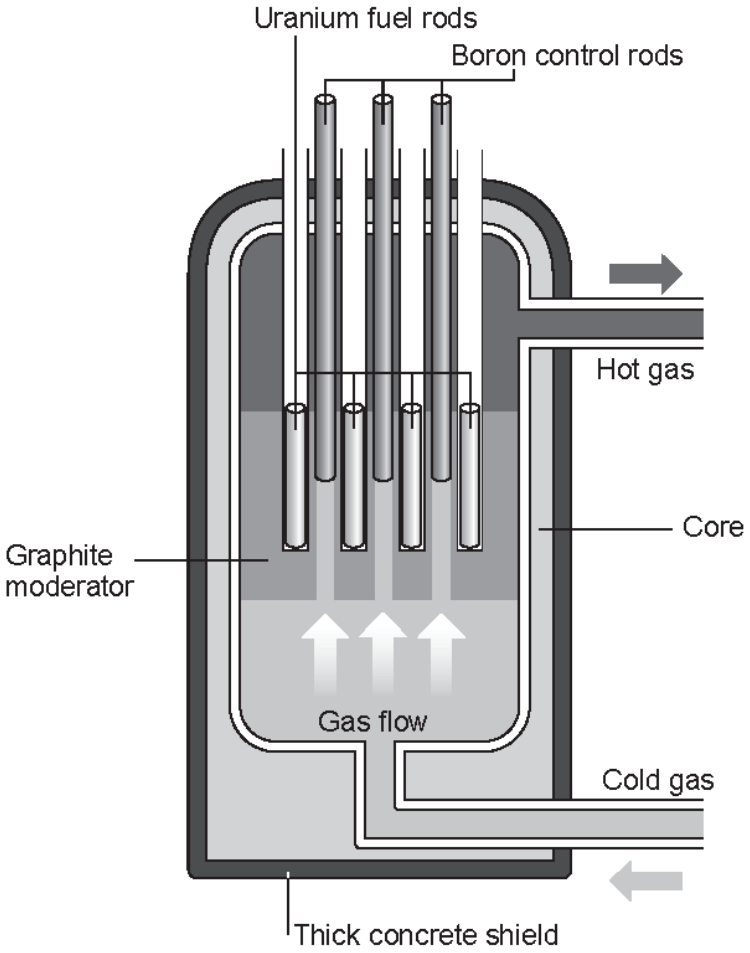
9.

Read the information in the passage and study the diagram before answering the questions that follow.
In the reactor, energy is released by fission and is the result of a controlled chain reaction. Fuel rods are made of uranium. The graphite moderator surrounds the fuel rods. The boron control rods can be raised and lowered.
The diagram shows the important parts in the core of a gas-cooled nuclear reactor.



(a) (i) Describe the process of fission of a single uranium nucleus in a gas-cooled reactor. [2]

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(ii) Explain the purpose of the graphite moderator. [2]

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(iii) Explain why raising the boron control rods increases the energy released in the reactor. [2]

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(b) The table below shows different isotopes of uranium (U).

Isotope	Nuclear symbol
U-230	$^{230}_{92}U$
U-234	$^{234}_{92}U$
U-235	$^{235}_{92}U$
U-238	$^{238}_{92}U$

(i) Tick (✓) the boxes next to **three** correct statements about the isotopes shown in the table. [3]

All the isotopes have nuclei which contain 92 neutrons ☐

A nucleus of U-230 contains the least number of neutrons ☐

A nucleus of U-235 contains 143 neutrons ☐

A nucleus of U-234 contains 92 protons ☐

A nucleus of U-238 contains 238 protons ☐

(ii) Complete the following nuclear equations which show the decay of two of the uranium isotopes listed in the table above. [2]

$$^{238}_{92}U \rightarrow {}^{4}_{2}He + {}^{.....}_{90}Th$$

$$..... \rightarrow {}^{4}_{2}He + {}^{230}_{90}Th$$

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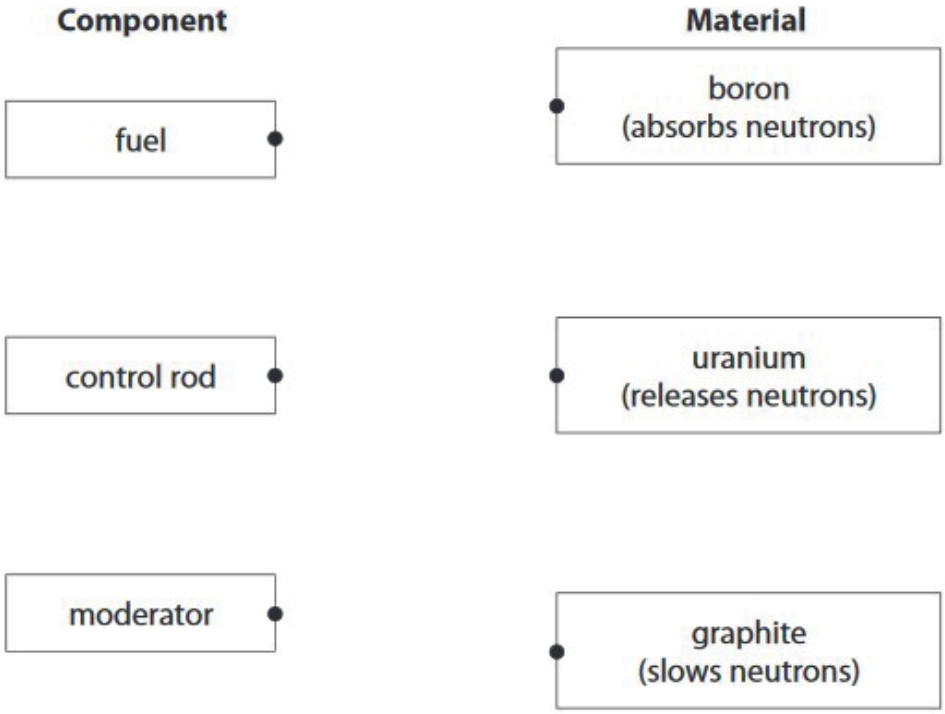
10.

(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)



(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 fission and nuclear fusion release thermal energy.

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.

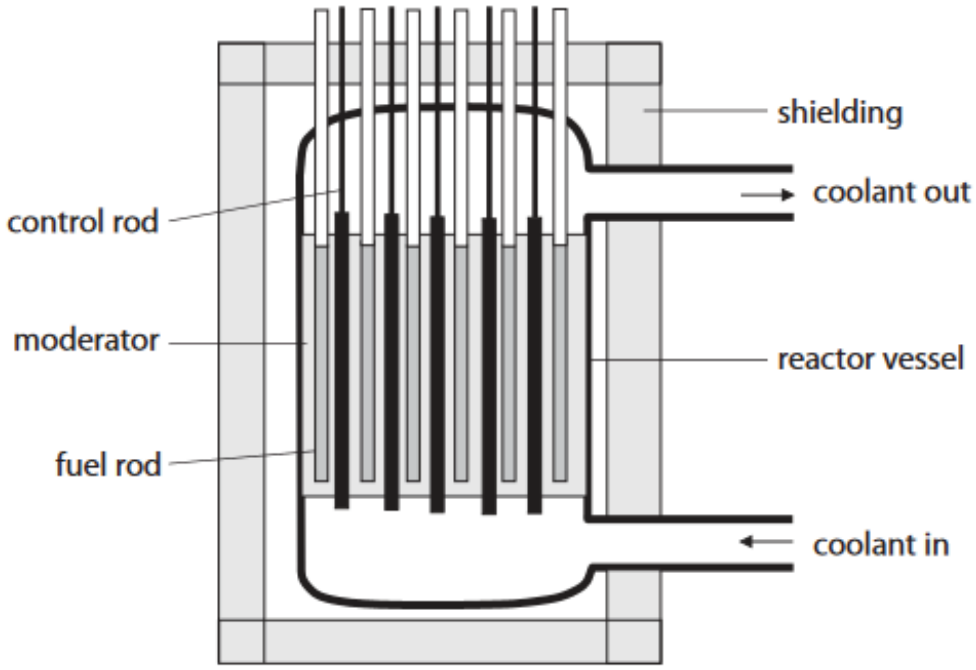
They have not been able to sustain the extreme conditions needed for controlled nuclear fusion.

Explain what these conditions are and why they are needed.

(6)

11.

The diagram shows the main parts of a nuclear reactor.



(a) Draw a line linking each part of the reactor with its main function.

The first one has been done for you.

(2)

part of reactor	main function
control rod	controls the rate of fission
coolant	absorbs dangerous radiation
fuel rod	contains uranium for fission
shielding	removes energy from the reactor

(b) State the type of energy released in a fission reaction.

(1)

(c) Explain the role of the moderator in a fission reaction.

(2)

(d) Explain, in terms of neutrons, what is meant by controlled nuclear fission.

(3)