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Student number

Name

Date

Attempt/Time taken

GCSE
PHYSICS

Topic Paper: 4.4 & 8.1.2 Nuclear fission and fusion and The life cycle of a star (Physics only)
Part 1

Time allowed: 40 minutes

Materials

For this paper you must have:

- the Periodic Table/Data Sheet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The Periodic Table/Data Sheet is provided as in insert.
- You are reminded of the need for good English and clear presentation in your answers.
- When answering questions you need to make sure that your answer:
  - is clear, logical, sensibly structured
  - fully meets the requirements of the question
  - shows that each separate point or step supports the overall answer.

34 Marks

Q1. Describe briefly how stars such as the Sun are formed.

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(Total 2 marks)

Q2. (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.

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(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.

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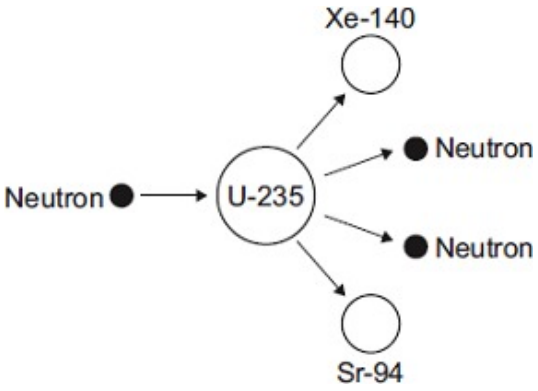
(3)

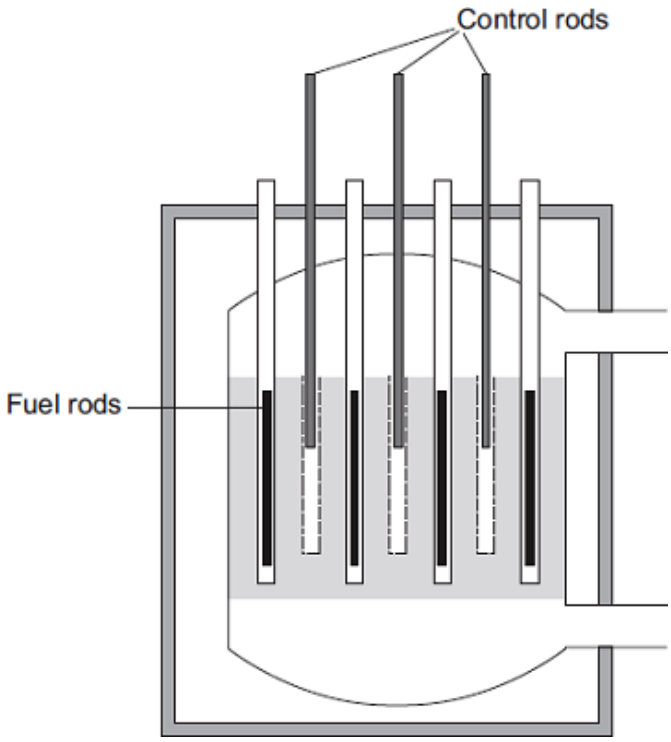
(b) The diagram shows the nuclear fission process for an atom of uranium-235.

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?

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(2)
(Total 8 marks)

Q3. (a) Nuclear power stations use the energy released by *nuclear fission* to generate electricity.

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

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(2)

(ii) How does nuclear fission lead to a chain reaction?

You may give your answer as a labelled diagram.

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(1)

(b) Although nuclear fuels are relatively cheap the total cost of generating electricity using nuclear fuels is expensive. Why?

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(1)

(c) The table compares the energy released from 1 kg of coal and 1 kg of uranium.

Coal	29 MJ
Uranium	580 000 MJ

1 MJ = 1 000 000 joules

State **one** benefit to the environment of using a concentrated fuel like uranium to generate electricity rather than using the energy from coal.

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(1)

(Total 5 marks)

Q4. The energy radiated by a **main sequence** star like the Sun is released by a nuclear fusion reaction in its core.

Read the following information about this reaction then use it to answer the questions below.

The net result of the nuclear fusion reaction is that four hydrogen nuclei produce one helium nucleus. There is a loss of mass of 0.7%.

For nuclear fusion to occur nuclei must collide at very high speeds.

The energy released during the reaction can be calculated as shown:

energy released [J] = loss of mass [kg] × (speed of light [m/s ^{2}])

(The speed of light is 3×10^8 m/s)

(a) Calculate the energy released when 1g of hydrogen fuses to form helium.

(*Show your working*.)

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(4)

(b) The table shows the lifetimes and surface temperatures of main sequence stars with different masses.

MASS OF STAR [SUN = 1]	LIFETIME ON MAIN SEQUENCE [MILLION OF YEARS]	SURFACE TEMPERATURE * [KELVIN]
0.5	200 000	4000
1	10 000	6000
3	500	11 000
15	15	30 000

[* The higher the surface temperature of a star, the higher the temperature and pressure in its core.]

(i) Describe the relationship between the lifetime of a main sequence star and its mass.

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(2)

(ii) Suggest an explanation for this relationship.

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(3)
(Total 9 marks)

Q5. (a) Explain how stars produce energy.

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(2)

(b) What evidence is there to suggest that the Sun was formed from the material produced when an earlier star exploded?

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(1)

(c) It is thought that gases from the massive star Cygnus X-1 are spiralling into a black hole.

(i) Explain what is meant by the term *black hole*.

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(2)

(ii) What is produced as the gases from a star spiral into a black hole?

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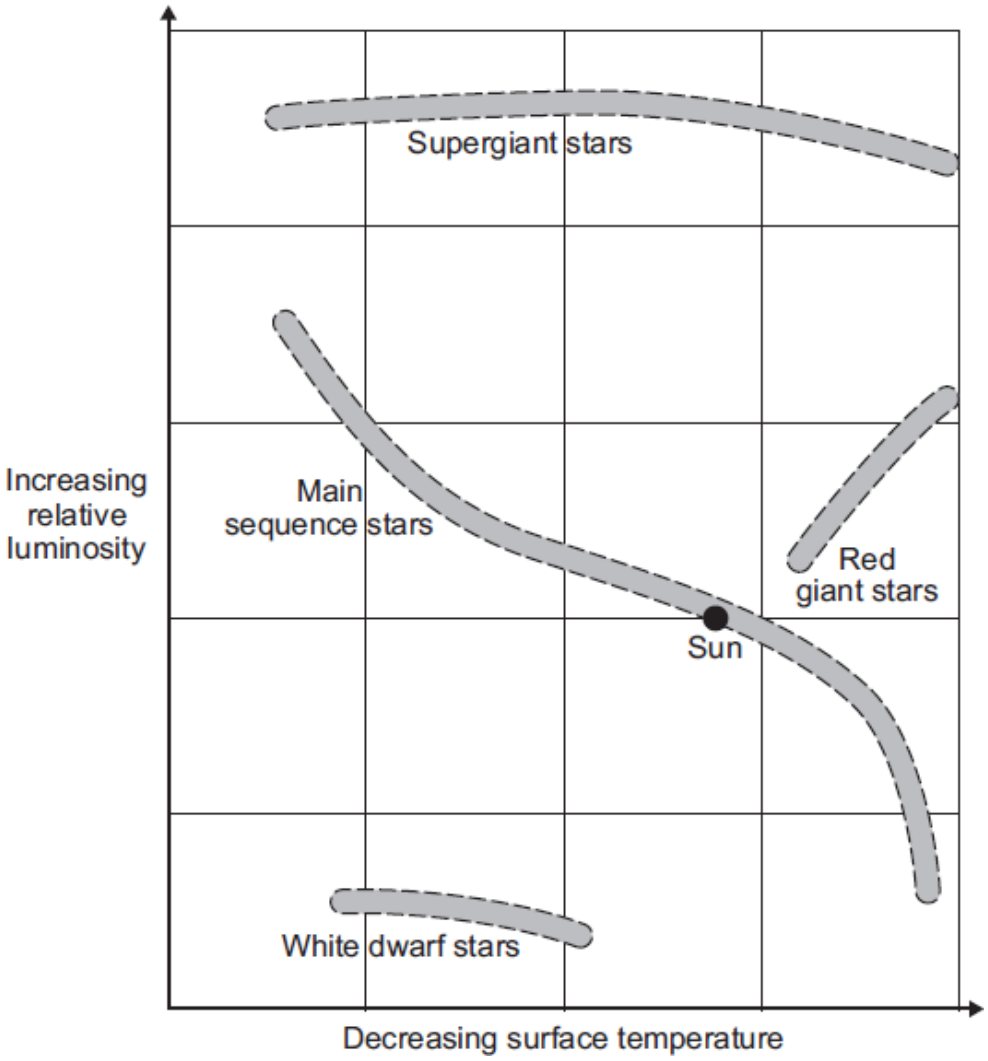
(1)

(Total 6 marks)

Q6. The diagram, drawn below, places stars in one of four groups.
Where a star is placed on the diagram is determined by the surface temperature and relative luminosity of the star.
A star with a relative luminosity of 1, emits the same amount of energy every second as the Sun.



(a) The Sun will spend most of its life cycle as a main sequence star. This is the stable period of the Sun's life cycle.

What happens to cause the stable period in the life cycle of a star to end?

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(1)

(b) Use the information in the diagram to describe what will happen to the Sun after the stable period ends.

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(3)
(Total 4 marks)