

Please write clearly in block capitals.

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

Surname

Forename(s)

Candidate signature

A-level ENVIRONMENTAL SCIENCE

Paper 1

Friday 7 June 2019

Morning

Time allowed: 3 hours

Materials

For this paper you may use:

- a calculator.

Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions 1 to 10 and **one** essay from question 11.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 120.
- All questions should be answered in continuous prose.
- You will be assessed on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
TOTAL	

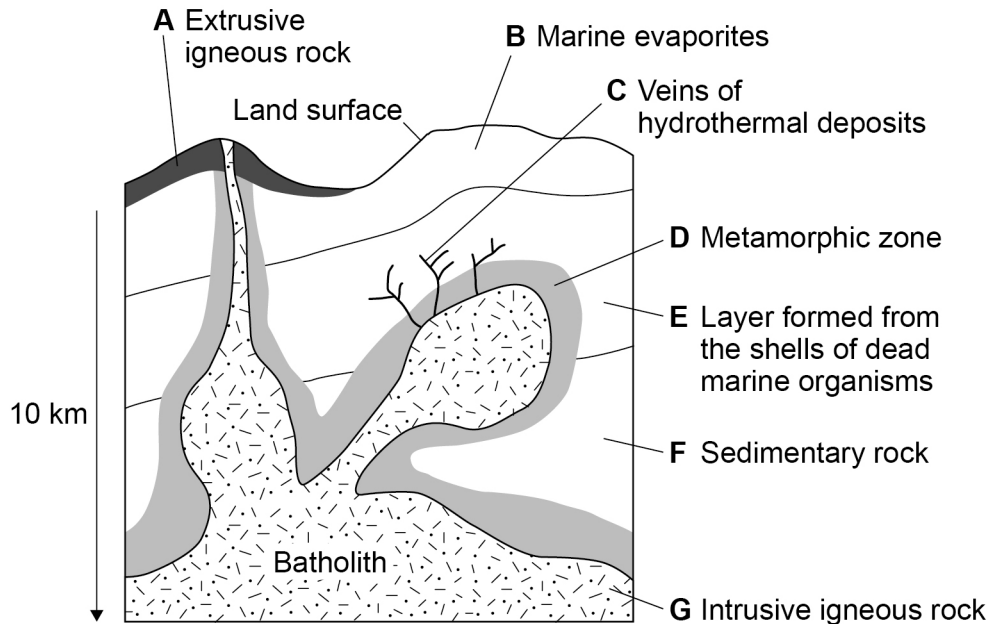


Answer **all** questions in the spaces provided.

0 1

Figure 1 shows a section through an area that was affected by ancient igneous activity.

Figure 1



Complete **Table 1** by selecting the appropriate letters from **Figure 1** to identify suitable locations for the rocks described.
One row has been completed for you.

[5 marks]

Table 1

Description	Letter
Igneous rock with small crystals, eg basalt	
Rock that contains large interlocking crystals, eg granite	
Rock with a grainy texture, eg sandstone	F
Rock affected by intense heat and pressure but without melting, eg marble	
Source of metals deposited from hot solutions, eg tin and lead	
Rock that contains large amounts of water-soluble mineral salts, eg sodium chloride	



0 2**Table 2** shows some features of four soils.**Table 2**

Soil feature	Soil			
	A	B	C	D
pH	6.7	6.1	4.3	7.2
water in original sample / % mass	28	30	28	20
organic matter content in dry soil / % mass	24	18	19	25
sand content in dry soil / % mass of mineral matter	33	25	15	52
silt content in dry soil / % mass of mineral matter	36	65	65	26
clay content in dry soil / % mass of mineral matter	31	10	20	22

0 2**1**

Use information from **Table 2** to suggest why soil **C** needs less irrigation than any of the other soils.

[1 mark]

0 2**2**

Explain why the use of heavy machinery is more likely to cause waterlogging of soil **A** than of the other soils.

[1 mark]

0 2**3**

During crop harvesting, roots and the lower part of the stems may be left in the field.

Explain how this technique may help to reduce the rate of soil erosion.

[2 marks]

Turn over ►

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD



WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.

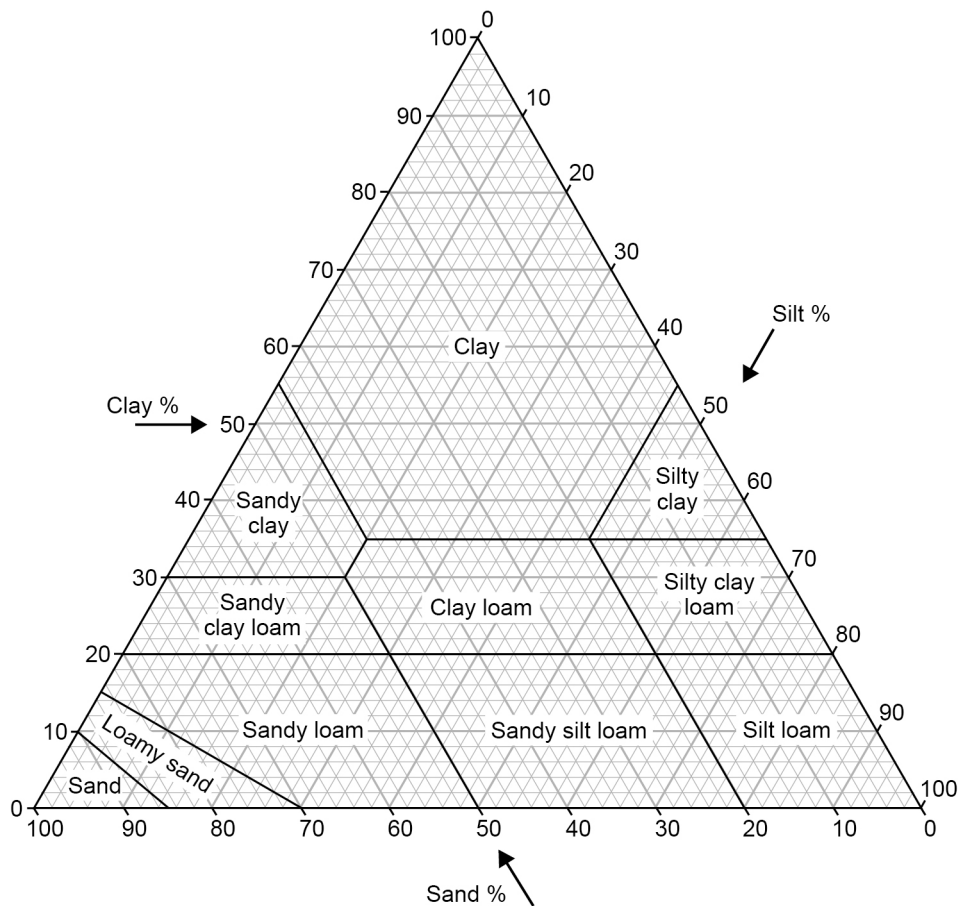


If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



Figure 2 shows a soil triangle used to identify soil type.

Figure 2



0 2 . 4

Use **Figure 2** to identify the soil type of soil **D** in **Table 2**.
Select **one** box only.

[1 mark]

A Clay loam

☐

B Sandy clay

☐

C Sandy clay loam

☐

D Sandy loam

☐

0 2 . 5

The organic matter content of a soil affects its fertility.

Outline **one** method that may be used to determine the percentage organic matter content of a soil sample.

[3 marks]

0 2 . 6

Explain why raising the pH of an acidic soil may increase its fertility.

[2 marks]

10

Turn over for the next question

Turn over ►



0 3

A study investigated the growth of three legume crops over one growing season. They were grown for the same length of time, in the same-sized plots, at the same planting density.

Table 3 shows information about three legume crops.

Table 3

Crop details		Legume crop		
		Common bean	Pea	Soybean
Above-ground crop	N-content / % of biomass	2.3	2.8	3.0
	Biomass / kg	1790	1700	2530
Seeds	N-content / % of biomass	25	25	40
Roots	N-content / % of biomass	2.1	2.2	1.7
	Biomass / kg	480	190	330
Total crop N-content / % of biomass		2.6	3.0	3.4
Total crop biomass / kg		2270	1890	2860
Source of N / %	Bacterial fixation	44	70	52
	Other sources	56	30	48

0 3 . 1

Use information from **Table 3** to calculate how much more nitrogen there was in the total soybean biomass than in the total common bean biomass.

Show your working.

[3 marks]

_____ kg



0	3	.	2
---	---	---	---

Use information from **Table 3** to calculate the mass of nitrogen in the pea crop biomass that was available due to bacterial fixation.

Show your working.

[2 marks]

_____ kg

0	3	.	3
---	---	---	---

Describe how **one** natural process increases the ammonium ion concentration of soil.

[1 mark]

Extra space _____

Question 3 continues on the next page

Turn over ►



The application of the principles of natural biogeochemical cycles is an important part of developing the Circular Economy.

[9 marks]

[illegible]

Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►

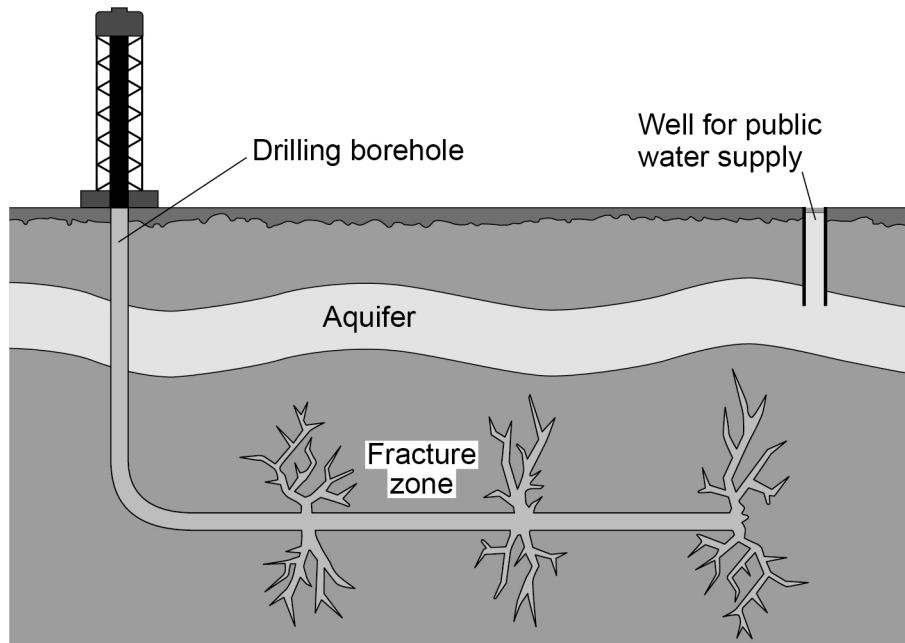


0 4

The combustion of natural gas produces less carbon dioxide per unit of energy released than burning oil or coal. The yield of natural gas from some sedimentary rocks can be increased using hydraulic fracturing. The early use of hydraulic fracturing caused environmental problems in some countries, but improved technology and better regulations have minimised these problems.

Figure 3 shows a cross-sectional diagram of a fracking borehole

Figure 3



0 4 . 1

Explain how hydraulic fracturing increases the recovery rate of natural gas.

[2 marks]



0	4	.	2
---	---	---	---

Explain how the environmental impacts of hydraulic fracturing can be reduced.

[3 marks]

5

Turn over for the next question

Turn over ►



0	5
---	---

Scientists investigated the effectiveness of using the aerobic bacterium *Pseudomonas fluorescens* to break down crude oil after pollution incidents.

Under laboratory conditions, sterile samples of saltwater were contaminated with crude oil hydrocarbons. Pure cultures of the bacterium were then transferred to each sample.

At 7-day intervals over 49 days, the scientists measured the:

- bacterial population
- concentration of hydrocarbons.

0	5	.	1
---	---	---	---

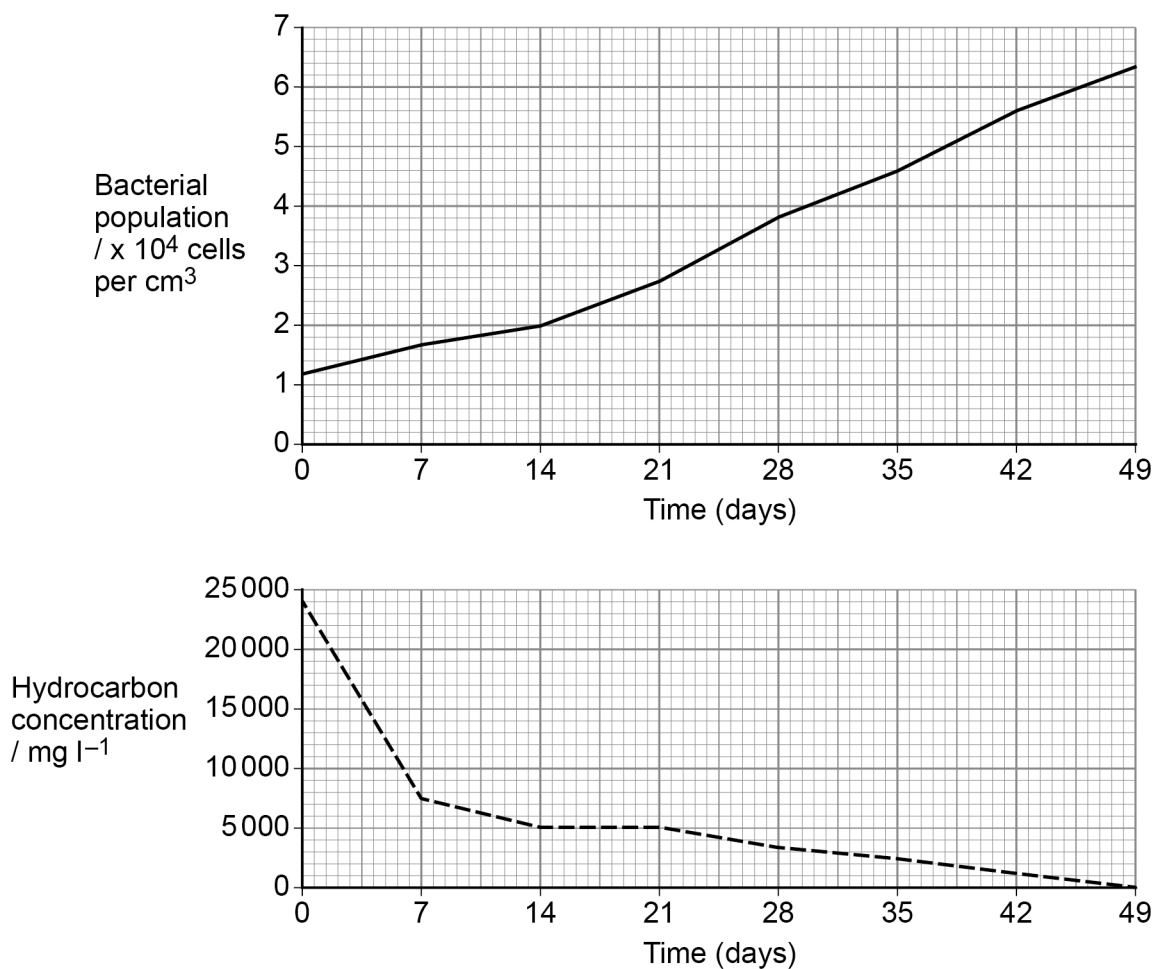
Suggest why the saltwater samples and all the equipment used had to be sterilised before the experiment started.

[2 marks]



Figure 4 shows the results of the experiment over the 49 days of the study.

Figure 4



0 5 . 2

Calculate the percentage increase in bacterial population over the 49-day period of the study.

Show your working.

[2 marks]

%

Question 5 continues on the next page

Turn over ►



0 5 . 3

The scientists used a statistical test to find whether the correlation between the concentration of hydrocarbons and the number of bacteria was significant. They calculated that the P value was less than 0.05.

What is the percentage probability that the data were produced by random chance?

[1 mark]

_____ %

0 5 . 4

The scientists concluded that this species of aerobic bacterium could be used effectively as a bioremediation treatment in the event of a crude oil spill.

Suggest **three** conditions under which bacterial bioremediation of oil spills may **not** be effective.

[3 marks]

1 _____

2 _____

3 _____

0 5 . 5

Chemical dispersants may also be used to clean up oil pollution. Suggest **one** advantage and **one** disadvantage of using chemical dispersants.

[2 marks]

Advantage _____

Disadvantage _____



0 6

A student investigated whether drainage water from a disused mine affected the biodiversity of invertebrates found in a stream.

0 6 . 1

Explain why water draining from mines often has a low pH.

[1 mark]

The student decided to sample three points along the stream at increasing distances from the mine. At each sampling point the student:

- measured the pH of the water
- used kick-sampling to collect samples of invertebrates.

0 6 . 2

Suggest **three** ways that the kick-sampling could have been standardised to ensure the data collected were reliable.

[3 marks]

Question 6 continues on the next page

Turn over ►

0	6	.	3
---	---	---	---

Biotic indices may be used to assess the levels of many pollutants, including acid pollution, in rivers.

Describe the features of species that would make them suitable for use in a biotic index.

[4 marks]

0	6	.	4
---	---	---	---

Suggest why the diversity of invertebrate species increased with distance downstream from the mine.

[2 marks]

10



Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



0 7

Ocean currents have been monitored using various methods to collect data such as velocity, water temperature and salinity.

Figure 5 and **Figure 6** show two methods of collecting data.

Figure 5 Argo floats

Nearly 4000 free-floating Argo floats have been deployed globally since 2000. The map shows the position of the Argo floats in the Atlantic Ocean on one day in 2018.

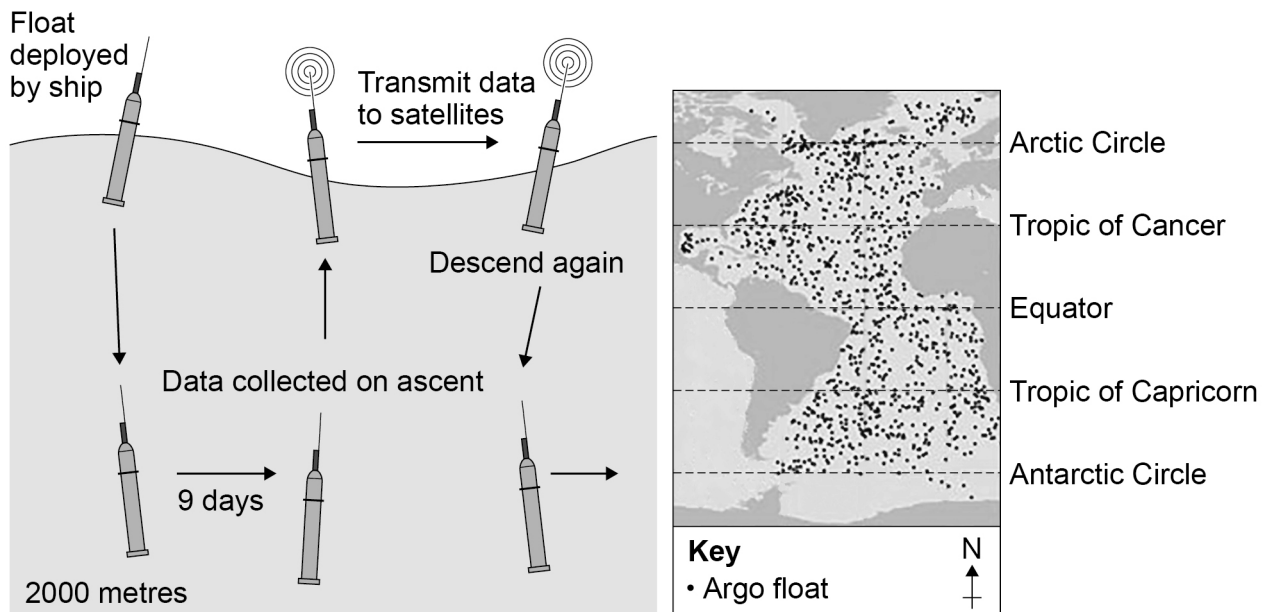
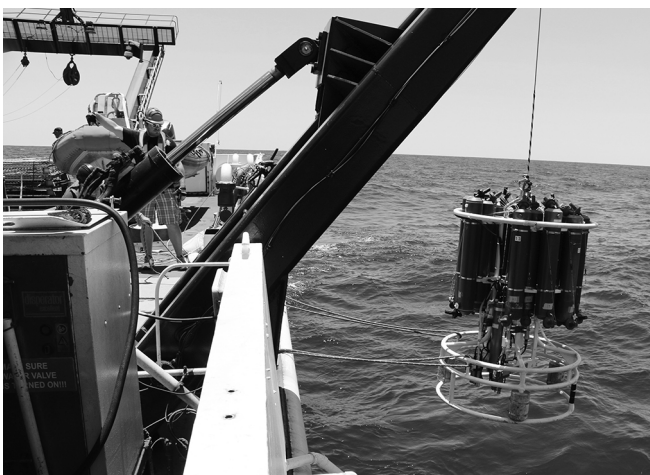


Figure 6 Ship-based surveys



Sea water is sampled from various depths using bottles attached by line to the ship.

The sea water is analysed on board the ship.



0	7	.	1
---	---	---	---

Use information in **Figure 5** and **Figure 6** and your own knowledge to outline **two** advantages of using Argo floats rather than ship-based surveys to collect data on ocean currents.

[2 marks]

Question 7 continues on the next page

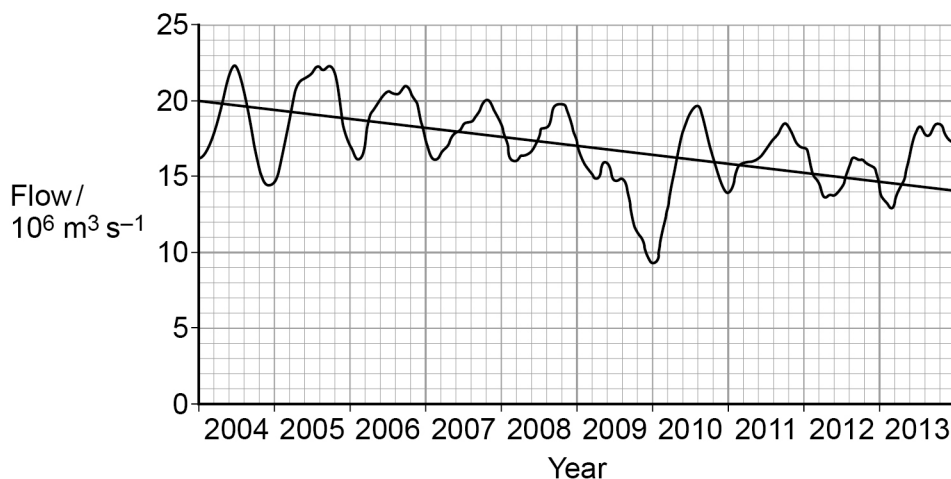
Turn over ►



Argo floats have been used to monitor the surface current of the North Atlantic Conveyor.

Figure 7 shows the change in the surface current of the North Atlantic Conveyor from 2004 to 2013.

Figure 7



0 7 . 2

Use the trend line in **Figure 7** to calculate the average annual reduction in surface flow of the North Atlantic Conveyor from the beginning of 2006 to the end of 2012.

Show your working

[1 mark]

_____ $\times 10^6 \text{ m}^3 \text{ s}^{-1}$

0 7 . 3

Explain how global climate change may result in a reduction in the flow of the North Atlantic Conveyor.

[3 marks]



Explain why it is difficult to predict accurately future changes in the flow of the North Atlantic Conveyor.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Turn over ►

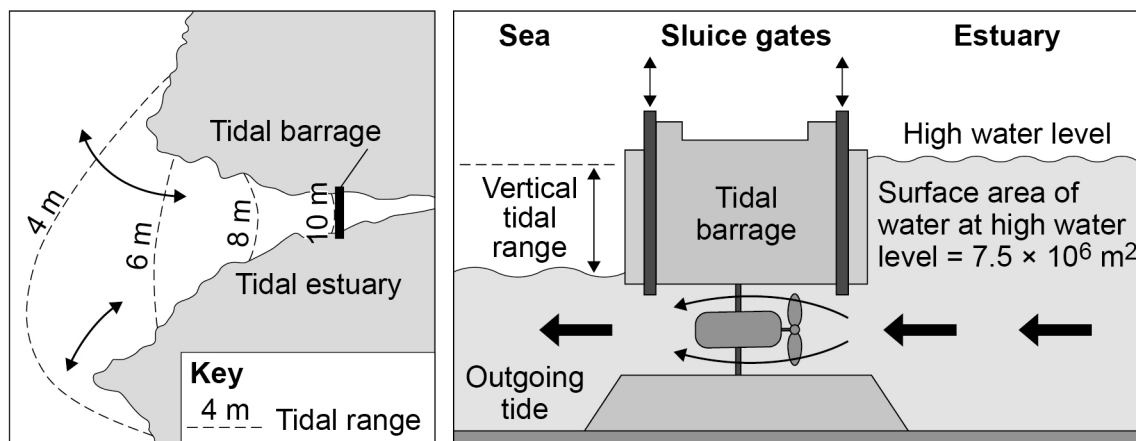


0 8

A tidal barrage is one method used to harness the energy of tidal flow in the sea.

Figure 8 shows the location and operation of a proposed tidal power scheme. Electricity is generated on the outgoing tide.

Figure 8



The potential energy of the water stored on the estuary side of the barrage at high water level is calculated using the formula:

$$PE = 0.5 A \rho g h^2$$

where

PE	potential energy available / J
A	surface area of water at high water level / m ²
ρ	density of sea water = 1025 kg m ⁻³
g	acceleration due to gravity = 9.81 m s ⁻²
h	vertical tidal range / m



0 8 . 1

To maximise the efficiency of the tidal barrage scheme and increase the mean power output, the sluice gates are closed for part of the outgoing tide. This increases the flow rate when the sluice gates are opened.

Use information in **Figure 8** and the formula to calculate the mean power output in megawatts (MW) of the tidal barrage if all the water flows out during a 3-hour period when the sluice gates have been opened.

Show your working.

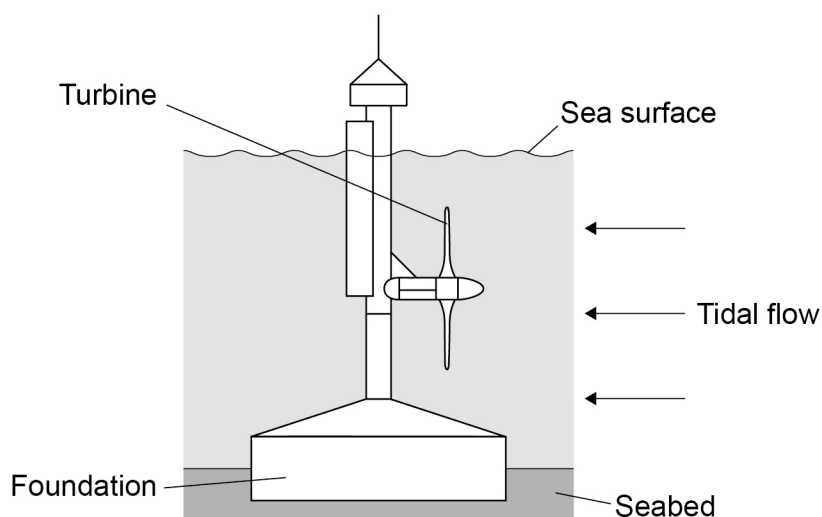
[2 marks]

_____ MW

In-stream tidal turbines may be used instead of a tidal barrage.

Figure 9 shows an example of an in-stream tidal turbine.

Figure 9



Question 8 continues on the next page

Turn over ►



Figure 10 shows the effect of increasing tidal stream velocity on the power output of a tidal turbine.

Figure 10

Figure 10 cannot be reproduced here due to third-party copyright restrictions.



0 8 . 2

Table 4 shows the relationship between tidal stream velocity and the efficiency of a tidal turbine.

Use the information in **Figure 10** to complete **Table 4**.

Show your working.

Table 4

Tidal stream velocity / m s^{-1}	Efficiency of tidal turbine / %
1.0	33
1.5	30
2.0	29
2.5	

[1 mark]

0 8 . 3

Explain why a tidal barrage scheme would provide a higher energy output than an in-stream tidal turbine scheme in the same location.

[2 marks]

Question 8 continues on the next page

Turn over ►



0	8	.	4
---	---	---	---

A tidal barrage changes the tidal flow and this affects the water turbidity and light penetration.

Describe an experiment to investigate the relationship between tidal flow and light penetration.

[5 marks]

Extra space

10



Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



0 9

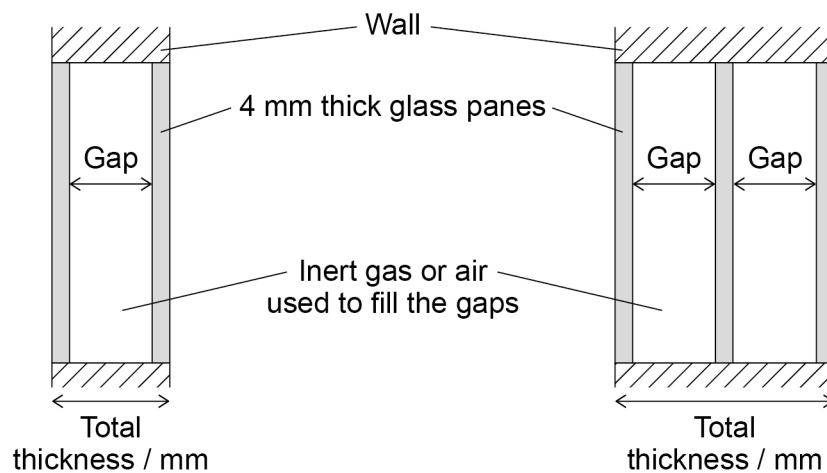
The effect of different window designs on heat transfer was investigated. Panes of glass of the same area and thickness were used to make double-glazed and triple-glazed windows, where the gap sizes and the type of gas used to fill the gaps were varied.

Figure 11 shows the arrangement of the panes of glass in double- and triple-glazed windows.

Figure 11

Cross-section of a double-glazed window

Cross-section of a triple-glazed window



The total gap size between the glass panes varies from 6 mm to 22 mm. Low emissivity (low-e) glass was used.

U values can be used as a measure of heat transfer. The U value measures the rate of energy loss through a 1 m^2 window with a temperature difference of 1°C . The lower the U value for the design of window, the less heat is transferred.



Four window designs were investigated:

- a double-glazed window filled with air
- a double-glazed window filled with inert gas
- a triple-glazed window filled with air
- a triple-glazed window filled with inert gas.

Figure 12 shows the U values of the four different window designs, W1, W2, W3, W4, with different overall thicknesses of windows.

Figure 12

Figure 12 cannot be reproduced here due to third-party copyright restrictions.

0 9 . 1

Use the information from **Figures 11** and **12** to select the line on the graph that is most likely to show the U values of a double-glazed window filled with an inert gas.

Shade **one** box only.

[1 mark]

A W1

☐

B W2

☐

C W3

☐

D W4

☐

Turn over ►



0 9 . 2

Use the information from **Figures 11** and **12** to calculate the optimum gap size between the panes of glass for window W1 that results in the smallest heat loss.

Shade **one** box only.

[1 mark]

A 6 mm

☐

B 16 mm

☐

C 22 mm

☐

D 24 mm

☐**0 9 . 3**

Use information from **Figures 11** and **12** and your own knowledge to explain how the design of windows can help to reduce heat loss.

[3 marks]

5

Turn over for the next question

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►

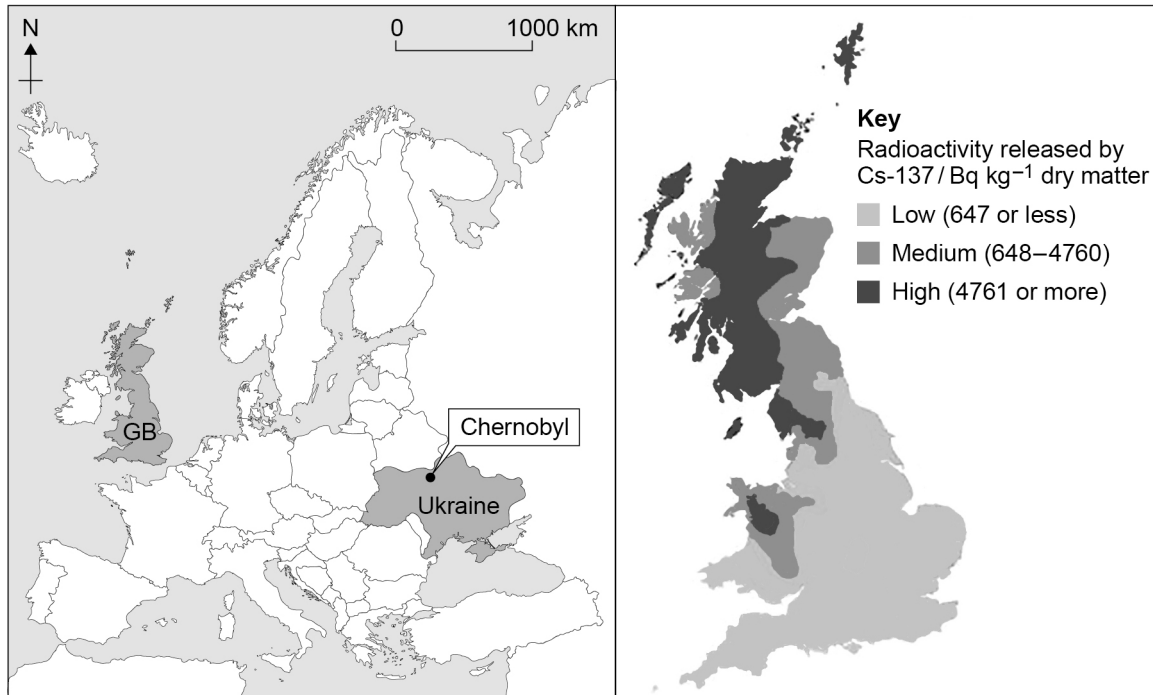


1 0

In April 1986, an explosion at the Chernobyl nuclear power plant in Ukraine caused the release of caesium-137 (Cs-137). One week later, raised levels of Cs-137 were detected in Great Britain. The level of Cs-137 in grass was surveyed. Samples were collected from sites across England, Scotland and Wales. The results were used to produce a map of Cs-137 contamination in grass.

Figure 13 shows a map of Europe with the location of Chernobyl and a map of Great Britain with levels of Cs-137 in grass in 1986.

Figure 13



1 0 . 1

Use the information in the text, **Figure 13** and your own knowledge to explain the regional variations in radioactivity released by Cs-137 in grass in Great Britain.

[3 marks]



1	0	.	2
---	---	---	---

Describe how the survey of Cs-137 in grass could have been planned to make sure the results were valid.

[5 marks]

Extra space

Question 10 continues on the next page

Turn over ►



Grass samples were taken from a farm in north west England in 1986. The radioactivity from Cs-137 in the grass samples was recorded. The grass samples were then stored for analysis of radioactivity in the future.

Table 5 shows details of Cs-137 and the amount of radioactivity recorded in the grass samples.

Table 5

Radioisotope	Half-life	Activity level of Cs-137 / Bq kg ⁻¹	
		1986	2076
Cs-137	30 years	12 072	

- 1 0 . 3** Use the information in **Table 5** to calculate the activity level of Cs-137 that will be present in the stored grass samples in 2076.

Write your answer in **Table 5**.

Show your working.

[1 mark]

- 1 0 . 4** Outline **one** factor used to identify individuals for a Critical Group Monitoring (CGM) study in Great Britain of the radioactive contamination from the Chernobyl accident.

[1 mark]

10



1	1	.	1
---	---	---	---

[25 marks]

11.2

[25 marks]

Question

1	1	.	1	
---	---	---	---	----------------------

☐

			
---	---	---	---

This image shows a single sheet of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page. There are approximately 20 lines visible. The paper has a slight shadow on its right side, suggesting it's resting on a surface.

[illegible]

Extra space

[illegible]

[illegible]

25



There are no questions printed on this page

*Do not write
outside the
box*

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright information

For confidentiality purposes, from the November 2015 examination series, acknowledgements of third-party copyright material are published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.aqa.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2019 AQA and its licensors. All rights reserved.

