A

Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

A-level
ENVIRONMENTAL SCIENCE

7447/1

Time allowed: 3 hours

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

JUN227447101

MATERIALS
For this paper you must have:
- **a calculator**

INSTRUCTIONS

- **Use black ink or black ball-point pen. Pencil should only be used for drawing.**

- **Answer ALL questions 1 to 10 and ONE essay from question 11.**

- **You must answer the questions in the spaces provided. Do not write on blank pages.**

- **If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).**

- **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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

0 4

0 1

Answer ALL questions in the spaces provided.

0 1 . 1

TABLE 1, on page 5, shows some technologies that can be used to help control pollution.

The table has been partially completed.

Complete TABLE 1, on page 5, by adding ONE MORE tick to each row. [5 marks]

TABLE 1

Control technology	Pollutant				
	Asbestos	Heavy metals	Oil	Pesticides	Radio-active waste
Adsorption by polymers			✓		✓
Bio-remediation		✓		✓	
Leachate collection					
Phyto-remediation			✓	✓	
Satellite monitoring					

5

0 2

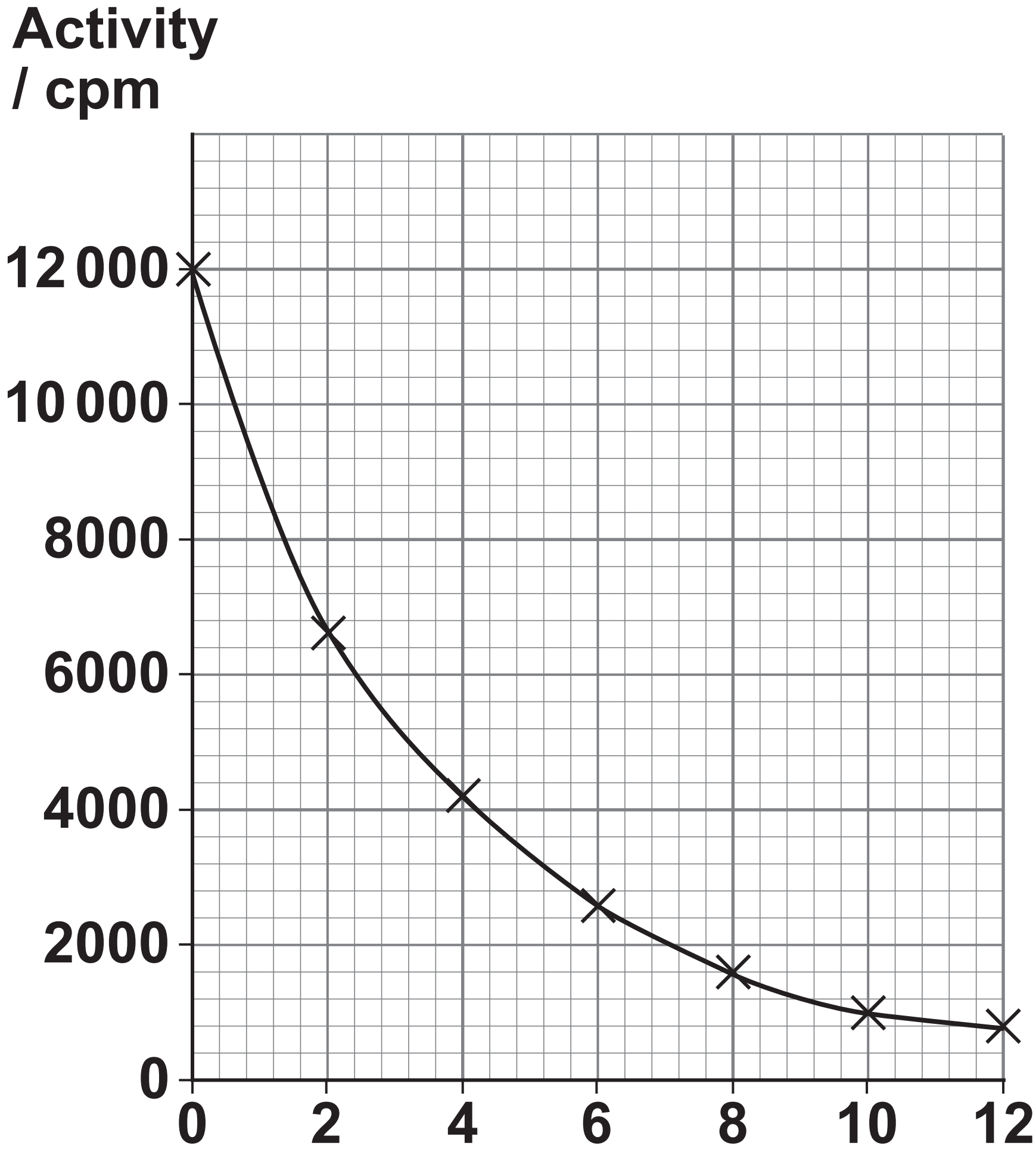
The potential increase in the use of nuclear power has resulted in new reactor designs, such as plutonium and thorium nuclear reactors.

0 2 . 1

Explain how the fuels used in plutonium and thorium nuclear reactors release energy that can be used to generate electricity. [4 marks]

[Turn over]

FIGURE 1



Barium-137m is a radioactive isotope formed from a fission product in a nuclear reactor.

The decay activity of barium-137m was recorded in counts per minute (cpm) using a Geiger counter.

The results are shown in FIGURE 1, on page 8.

0 2 . 2

Use FIGURE 1, on page 8, to calculate the half-life of barium-137m. [1 mark]

Half-life _____ min

TABLE 2 shows details of some radioactive isotopes produced in nuclear reactors.

TABLE 2

Isotope	Half-life	Type of radiation emitted
Technetium-99	300 000 years	Beta
Barium-133	11 years	Gamma
Polonium-210	138 days	Alpha
Strontium-90	29 years	Beta
Caesium-137	30 years	Beta and Gamma

0 2 . 3

Use information in TABLE 2, on page 10, to suggest how the half-life of technetium-99 may make it a lower risk to health than strontium-90. [1 mark]

0 2 . 4

Explain which of the isotopes in TABLE 2, on page 10, poses the greatest health risk if ingested. [2 marks]

Isotope _____

Explanation _____

0 2 . 5

Outline ONE named method that is used to manage high-level radioactive waste from nuclear power stations. [2 marks]

[Turn over]

0 3

TABLE 3 shows current estimated values for the main carbon reservoirs in the carbon cycle.

TABLE 3

Reservoir	Main components	Amount of carbon/Gt
Atmosphere	Carbon dioxide	700
	Methane	1.2
Biosphere	Living organisms	470
	Dead organic matter	3 700
Hydrosphere	Dissolved carbon dioxide and hydrogen carbonate ions	35 500
Lithosphere	Carbonates in rocks	20 000 000
	Fossil fuels	10 000

0 3 . 1

The amount of carbon dioxide in the atmosphere has increased by 47% since 1850.

Use TABLE 3, on page 14, to calculate the amount of carbon in carbon dioxide in the atmosphere in 1850.

Give your answer in tonnes.

Give your answer in standard form to an appropriate number of significant figures.

[Turn over]

Show your working. [2 marks]

t

0 3 . 2

For each of the reservoirs listed below, explain one way that the amount of carbon may have changed since 1850. [3 marks]

Biosphere

Hydrosphere

Lithosphere

[Turn over]

0 3 . 3

Two methods that may be used for the sustainable management of the carbon cycle are:

- **carbon sequestration**
- **carbon capture and storage (CCS).**

Describe ONE similarity and TWO differences between these two methods. [3 marks]

Similarity _____

_____

_____

Difference 1 _____

_____

_____

Difference 2 _____

_____

_____

0 3 . 4

Give TWO OTHER methods for the sustainable management of the carbon cycle. [2 marks]

1 _____

_____

_____

2 _____

_____

_____

10

[Turn over]

0 4

TABLE 4 shows two ways of measuring the energy density of some biofuels.

TABLE 4

Biofuel	Energy per unit mass / MJ kg^{-1}	Energy per unit volume / MJ l^{-1}
Biodiesel	38	33.3–35.7
Elephant grass	13	1.8–2.3
Straw	15–19	1.6–16.6
Sunflower oil	39	33.2
Wood	15–21	2.6–21.8

0 4 . 1

Suggest why reporting energy density as energy per unit mass might be more useful than as energy per unit volume.
[2 marks]

0 4 . 2

Suggest TWO reasons why the data for wood and straw are more variable than for the other biofuels. [2 marks]

1 _____

2 _____

0 4 . 3

Elephant grass has a lower energy density compared with many other biofuels but it is grown as a biofuel crop in many different parts of the world.

Suggest TWO reasons why so much elephant grass is grown. [2 marks]

1 _____

_____

_____

2 _____

_____

[Turn over]

0 4 . 4

Describe the advantages and disadvantages of biofuels compared with other renewable energy sources. [4 marks]

Advantages _____

Disadvantages ______________________________

____

____

____

____

____

____

____ 10

[Turn over]

0 5

Insulating materials are used to reduce heat loss from different parts of a house.

Fibreglass is often used in loft spaces to reduce heat loss through a roof.

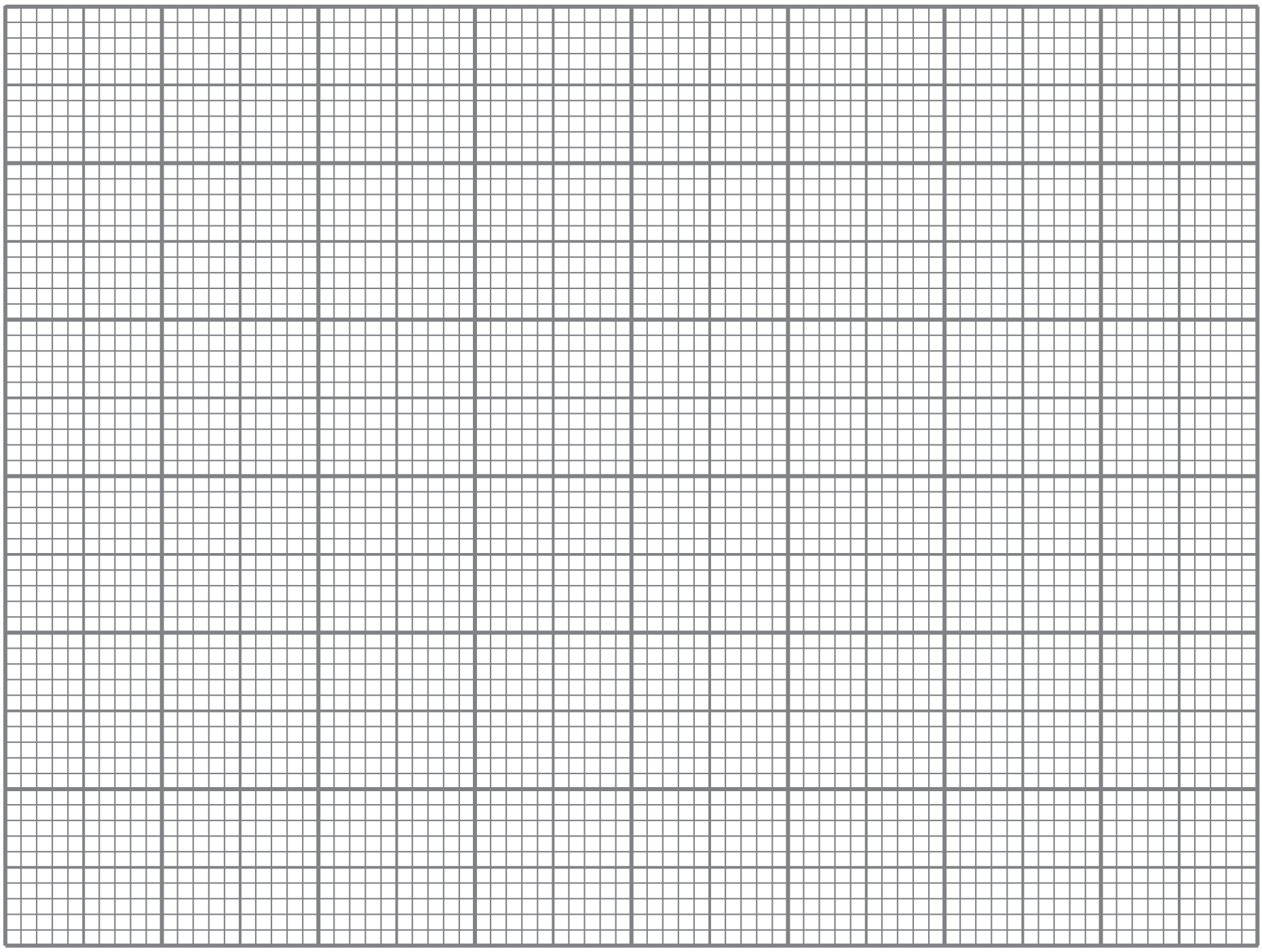
TABLE 5 gives data of U values (heat loss) for different thicknesses of fibreglass insulation.

TABLE 5

Thickness of fibreglass insulation / mm	U value / W m^{-2} °C
0	1.20
25	0.80
50	0.60
75	0.45
100	0.30
150	0.18
200	0.16
300	0.12

0 5 . 1

Use the information in TABLE 5, on page 26, to plot a graph showing how heat loss varies with the thickness of fibreglass insulation. [2 marks]



[Turn over]

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0 5 . 2

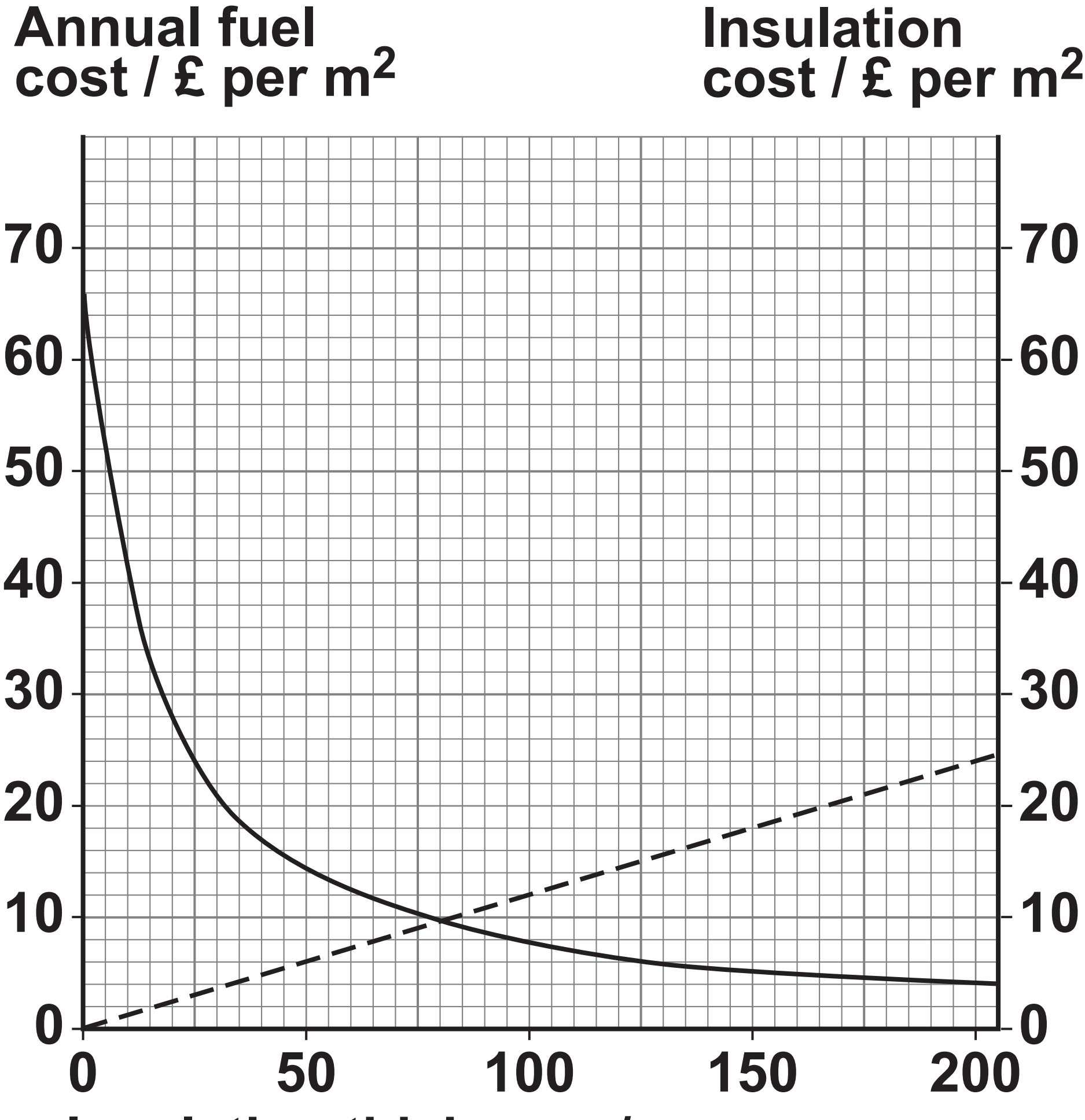
Use the graph to suggest why the optimum thickness of fibreglass insulation used in a loft space is 100 mm. [2 marks]

FIGURE 2, on page 31, shows the costs involved in a loft insulation project. The annual fuel cost for space heating and the purchase and installation costs of fibreglass of different thicknesses are shown.

0	5	.	3

Use FIGURE 2 to explain which thickness of fibreglass in this loft insulation project is the economic optimum over one year. [2 marks]

FIGURE 2



[Turn over]

0 5 . 4

Students investigated THREE different types of insulating material to see which was most effective at reducing heat loss from a container of water.

Outline how the students should have designed their investigation. [4 marks]

10

[Turn over]

0 6

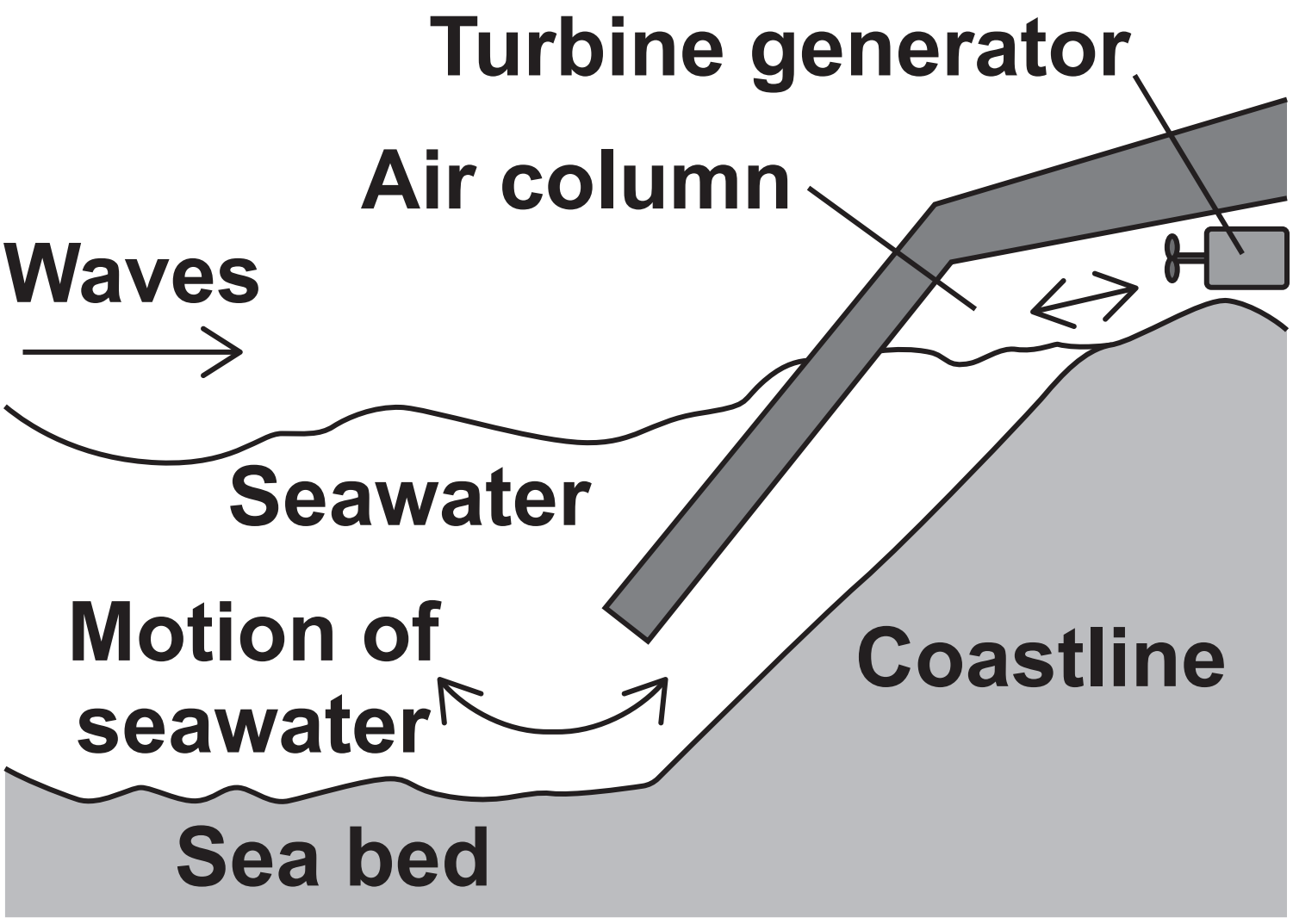
The energy of waves can be used to produce electricity.

FIGURE 3 shows five wave energy devices, W1–W5.

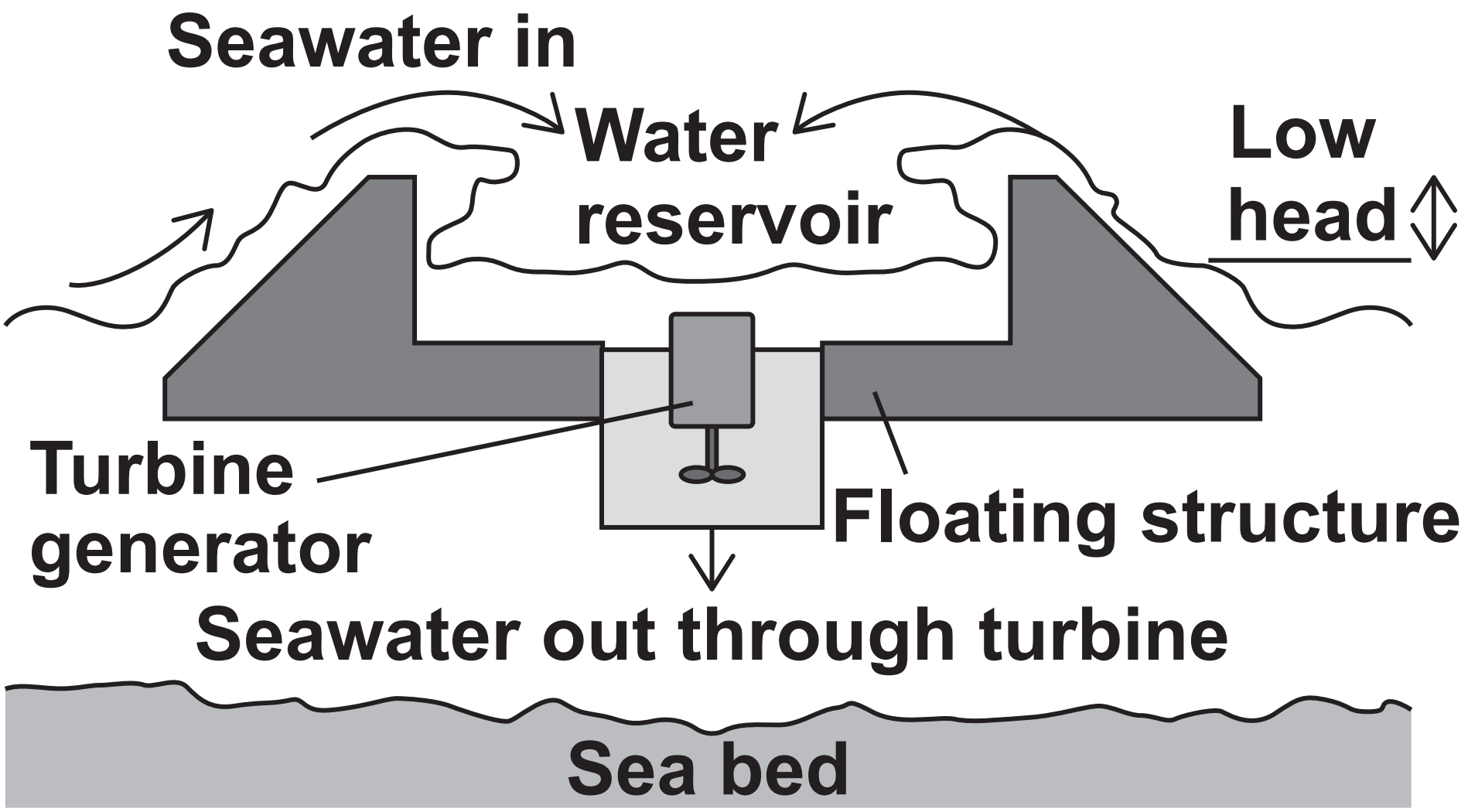
Not drawn to scale

FIGURE 3

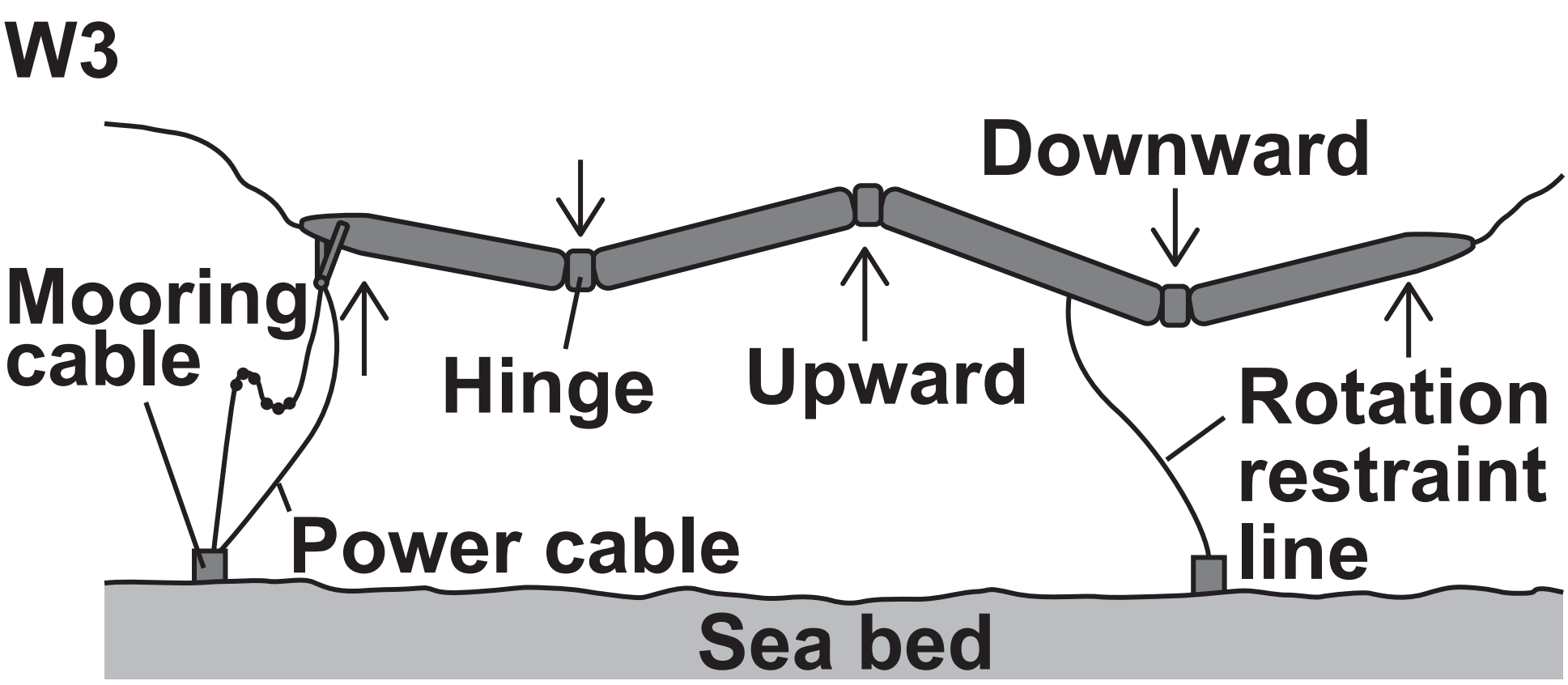
W1



W2

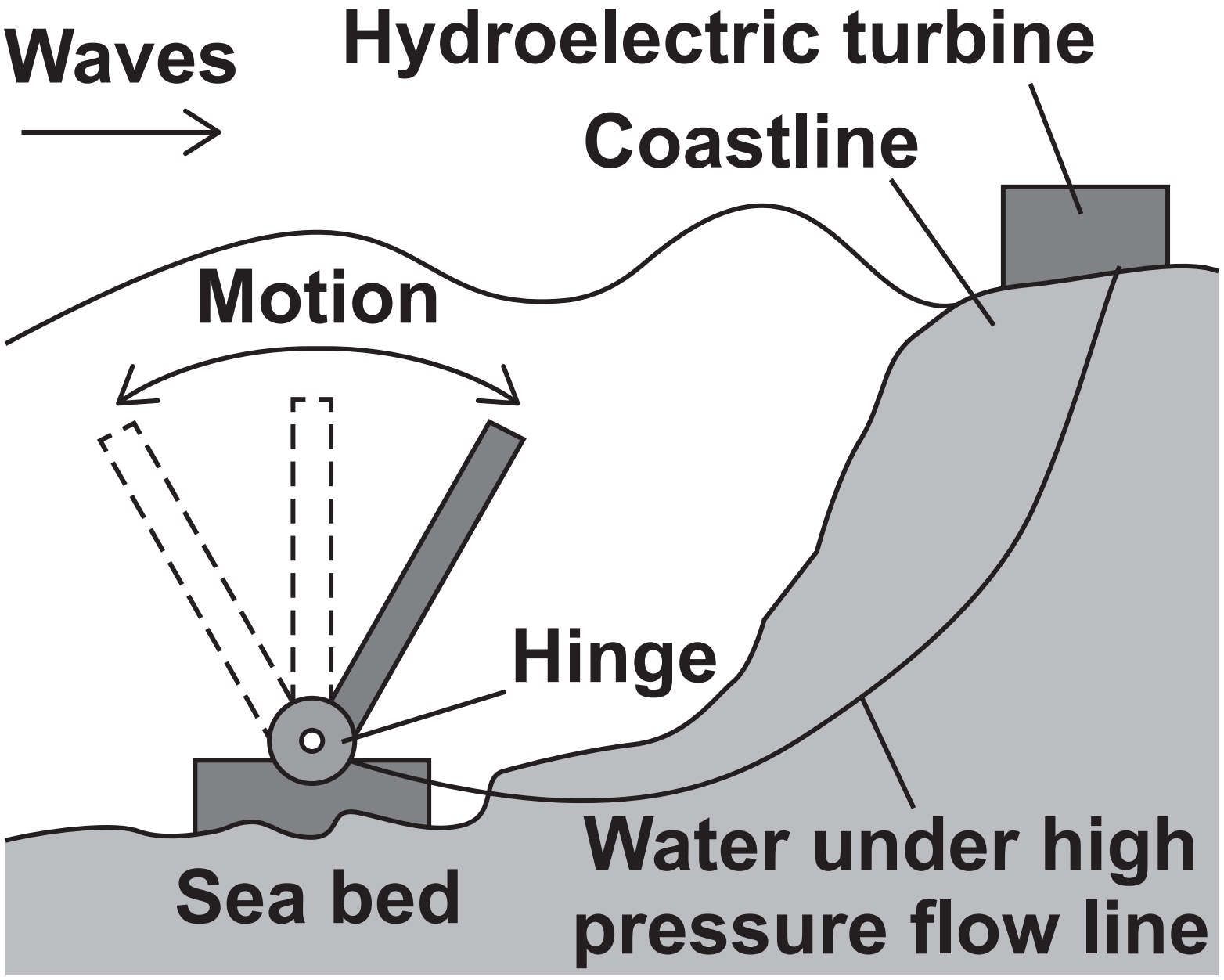


W3

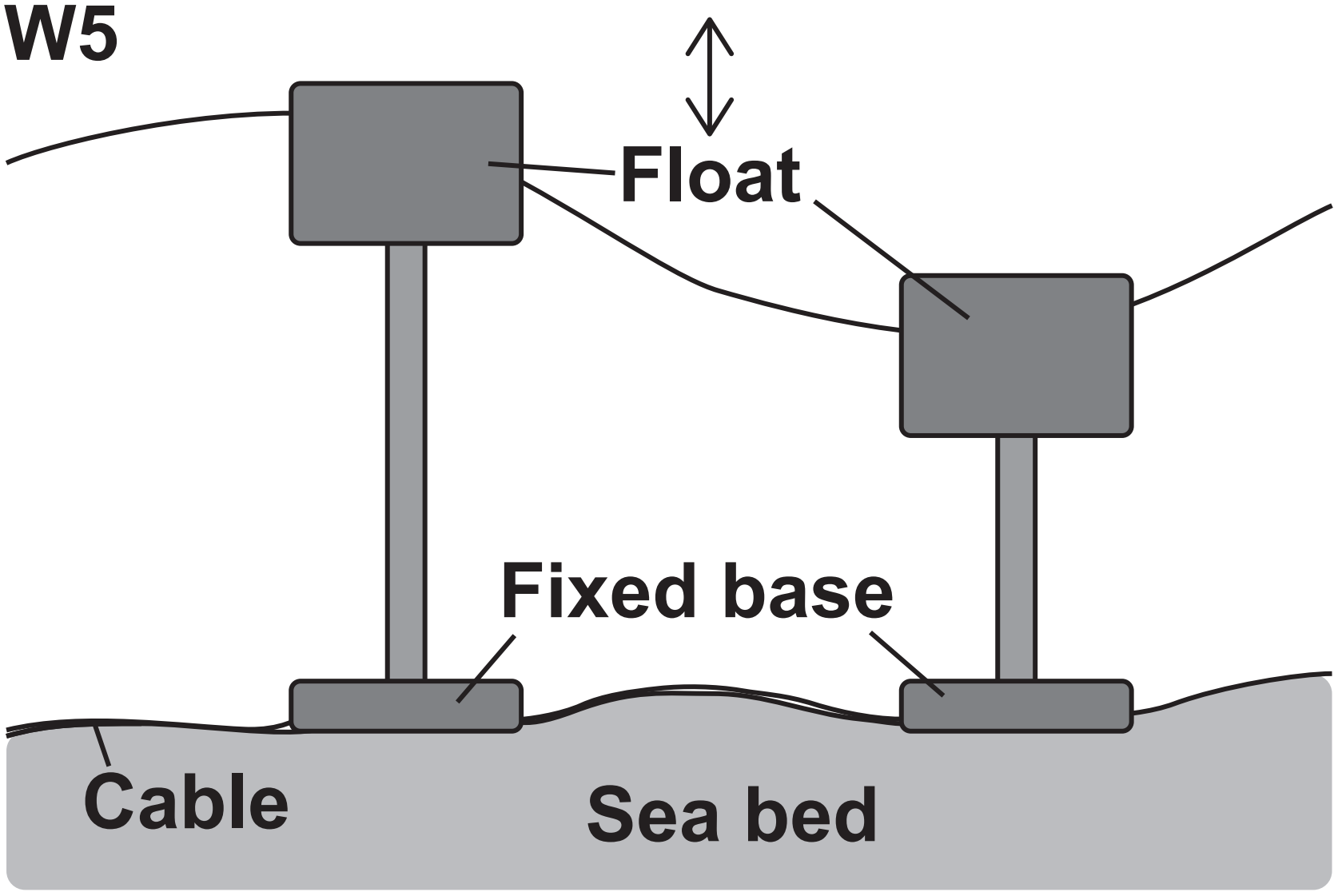


[Turn over]

W4

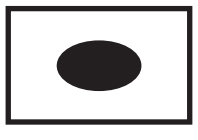

Waves
Hydroelectric turbine
Coastline
Motion
Hinge
Sea bed
Water under high pressure flow line

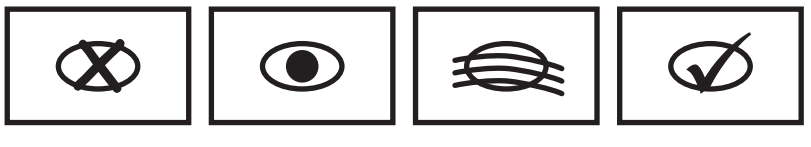
W5

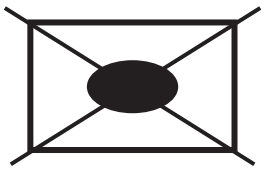

Float
Fixed base
Cable
Sea bed

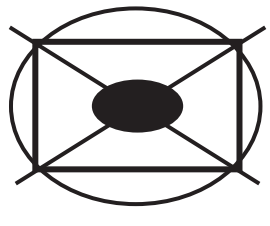
Only ONE answer per question is allowed.

For each question 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. 

[Turn over]

0 6 . 1

Which wave energy device uses gravitational energy to produce electricity?

Shade ONE box only. [1 mark]

A W1 ⬭

B W2 ⬭

C W3 ⬭

D W4 ⬭

E W5 ⬭

0 6 . 2

Which wave energy devices can extract energy from waves moving in any direction?

Shade ONE box only. [1 mark]

A W1 and W2 ⬭

B W1 and W3 ⬭

C W2 and W4 ⬭

D W2 and W5 ⬭

E W3 and W5 ⬭

[Turn over]

0 6 . 3

The research and development of a wave energy device involves calculating its capacity factor.

This involves comparing the actual annual output of electricity in MWh to the output of electricity in MW if the device worked at maximum capacity.

The capacity factor is calculated by use of the formula:

$$\text{Capacity factor (\%)} = \frac{\text{actual annual output}}{\text{potential maximum annual output}} \times 100\%$$

The capacity factor of a wave energy device is 36% and its potential maximum annual output rating is 1 MW.

Use this information and the equation above to calculate its actual annual output in MWh.

Give your answer to an appropriate number of significant figures.

Show your working. [3 marks]

MWh

5

[Turn over]

0 7

Atmospheric particulate matter less than 10 µm in diameter is written as PM10.

A gravimetric particle analyser is an instrument used to measure levels of PM10 by sampling air.

A known volume of air is passed over a filter. The filter is weighed before and after the sampling period to determine the mass of PM10 trapped.

FIGURE 4, on page 43, is a diagram of a gravimetric particle analyser.

Not drawn to scale

FIGURE 4

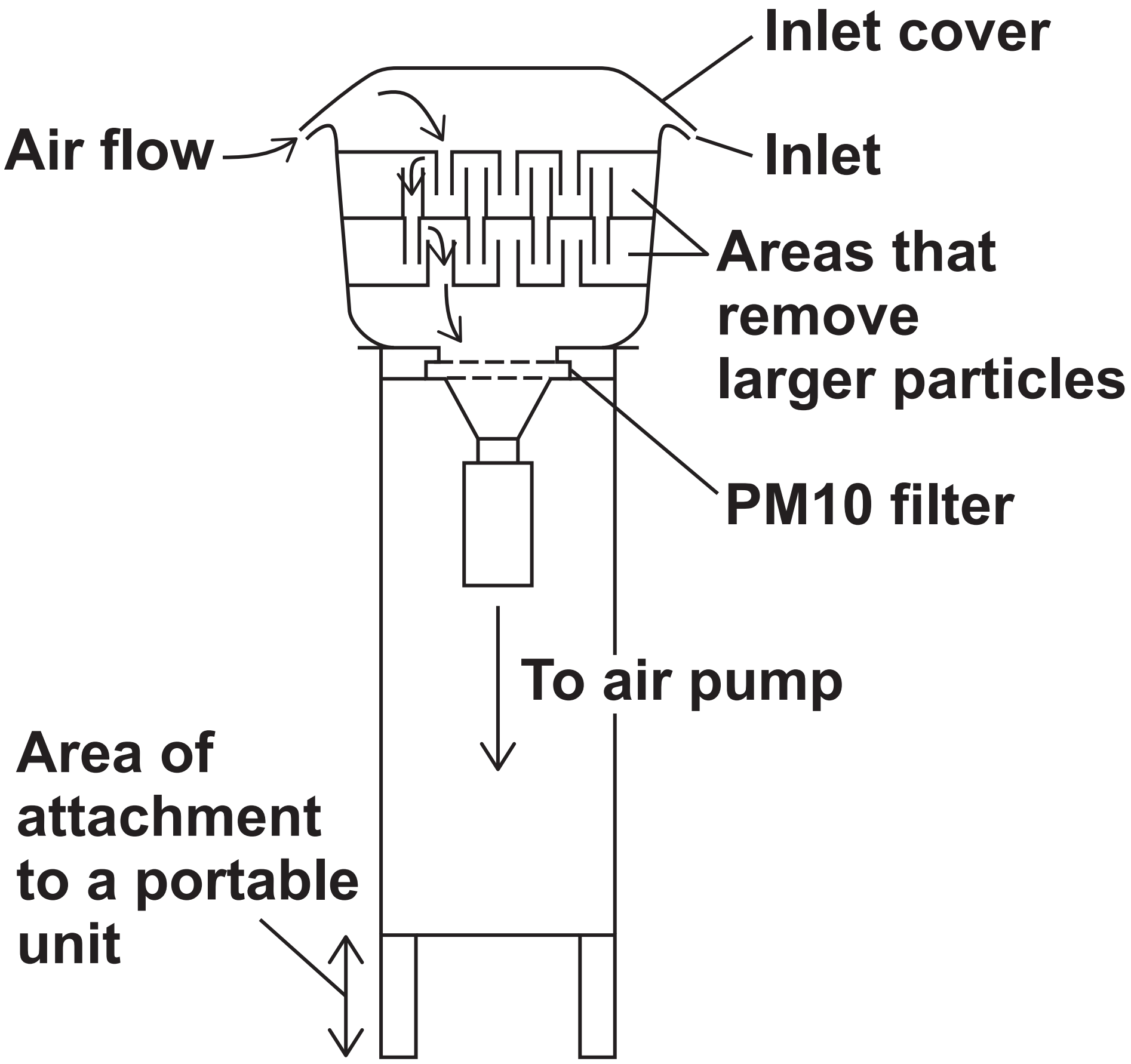


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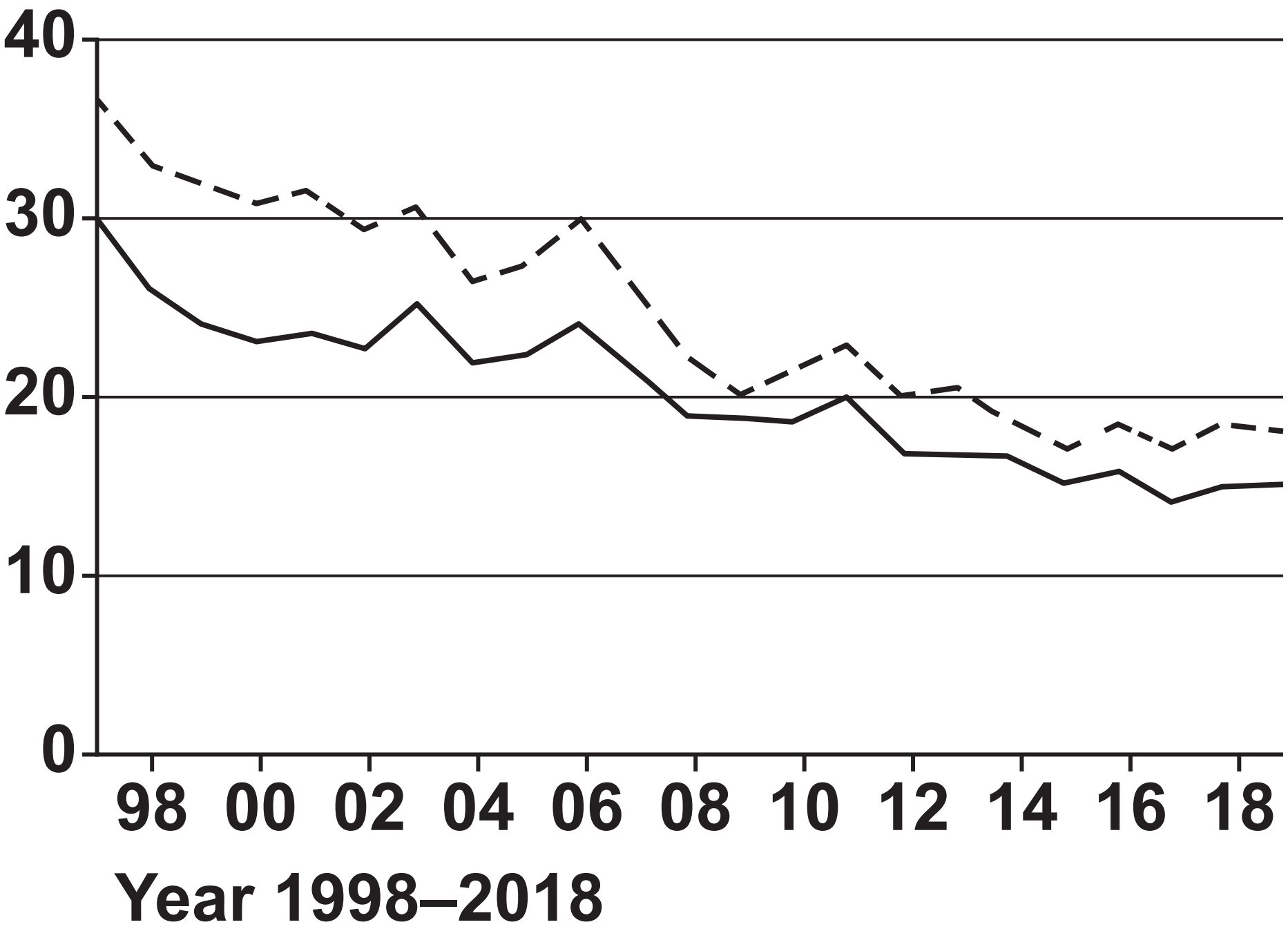
FIGURE 5



KEY

– – – **Roadside = sample sites located within 5 m of the roadside**

—— **Urban background = sample sites located in urban residential areas away from specific emission sources**

[Turn over]

FIGURE 5, on page 45, shows annual mean PM10 concentrations from roadside and urban background sample sites in the UK from 1997 to 2019.

0	7	.	1

To obtain comparable results for PM10 concentration levels from roadside and urban background areas, suggest THREE variables that would need to be standardised when sampling air using a gravimetric particle analyser. [3 marks]

Variable 1 _____

_____

_____

Variable 2 _____

_____

_____

Variable 3 _____

_____

_____

0 7 . 2

Suggest ONE limitation of using a gravimetric particle analyser to measure the concentration of PM10. [1 mark]

_____

_____

_____

[Turn over]

0 7 . 3

Outline the reasons for the trends shown in the PM10 concentration levels in roadside and urban background areas in FIGURE 5 on page 45. [3 marks]

BLANK PAGE

[Turn over]

0 7 . 4

Explain why PM10 samples vary at different times of the year. [3 marks]

10

[Turn over]

5 1

0 8

Normally, winds near the equator blow westwards across the Pacific Ocean, from South America towards Asia and Oceania (Australasia).

These winds move the surface ocean current in the same direction.

During El Niño periods, the directions of the wind and surface ocean current are reversed and move eastwards.

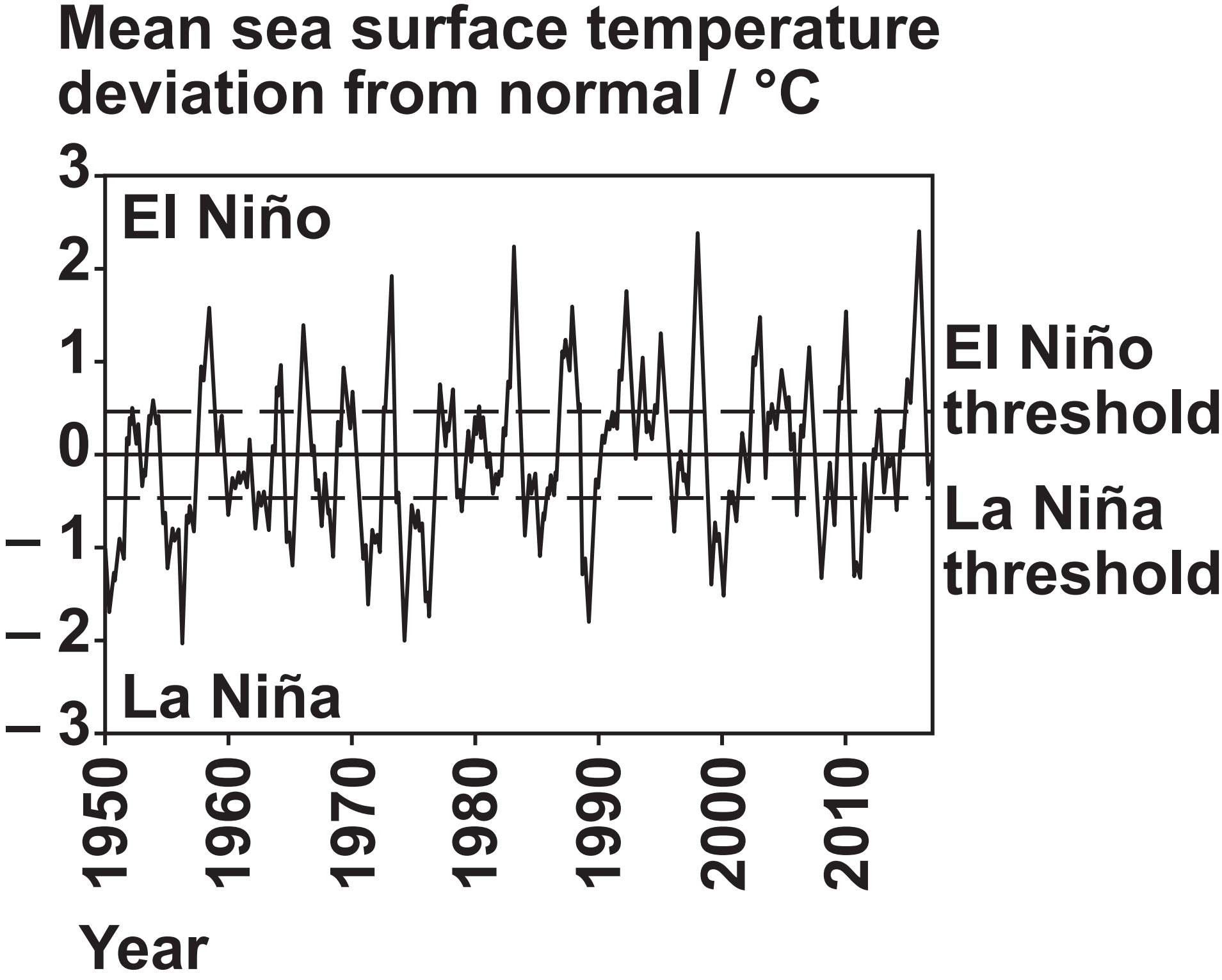
This causes the surface sea temperature to rise above normal.

There are also periods, known as La Niña, when the wind and surface ocean current move westwards, but more quickly than normal.

This causes the surface sea temperature to fall below normal.

FIGURE 6 shows the mean sea surface temperature deviation from normal for 1950–2017 measured in the equatorial Pacific Ocean.

FIGURE 6



[Turn over]

0 8 . 1

The sea surface temperature was monitored continuously. The results were used to calculate means for each three-month period. These means were used to plot the graph in FIGURE 6, on page 53.

Suggest why a three-month period was used. [2 marks]

0 8 . 2

Suggest why temperature deviations must exceed thresholds to be classed as either El Niño or La Niña. [1 mark]

0 8 . 3

Scientists are concerned about what could happen if El Niño events become more intense or more frequent.

Use FIGURE 6, on page 53, to evaluate whether El Niño events have become more intense or more frequent. [4 marks]

0 8 . 4

Scientists are concerned that if El Niño events become more intense or more frequent in the future they may reach an environmental tipping point.

Define the term ‘tipping point’. [1 mark]

0 8 . 5

Explain why scientists are concerned about environmental tipping points.
[2 marks]

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[Turn over]

0 9

Students collected soil samples from different locations in a field. They analysed each sample to find its water content and its organic matter content.

TABLE 6 shows some of their results.

TABLE 6

Location	A	B	C	D	E
Wet soil mass / g	48.3	50.3	49.8	49.3	48.9
Dry soil mass / g	38.7	41.1	39.6	36.6	37.8
Burnt soil mass / g	31.6	34.6	33.2	29.8	31.1
Organic matter content / %	18.3	15.8		18.6	17.7

0 9 . 1

Describe how the students should make sure their set of soil samples is representative of the field. [2 marks]

0 9 . 2

Describe the methods to get the results for dry soil mass and burnt soil mass.
[4 marks]

0 9 . 3

Use data from TABLE 6, on page 60, to calculate the percentage (%) organic matter content in dry soil sample C.

Give your answer to ONE decimal place.

Show your working. [2 marks]

_____ %

[Turn over]

0 9 . 4

The students compared their results for the percentage (%) organic matter content with those from another field.

Outline how the students should analyse their results to decide if there is a significant difference between the percentage (%) organic matter content of the soil in the two fields. [2 marks]

10

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[Turn over]

TABLE 7

Stage	Description
Pre-treatment	
Primary treatment	Effluent is stored in tanks and the faecal solids sink to the bottom. The sludge that is formed at the bottom is then removed.
Secondary treatment	
Tertiary treatment	

1 0

Many organic wastes are treated before they are discharged into rivers or the sea.

TABLE 7, on page 66, shows the main stages in the treatment of sewage.

1 0 . 1

Complete TABLE 7 by describing what happens at each stage.

One stage has been done for you. [6 marks]

[Turn over]

1 0 . 2

Some wastes can cause pollution when they enter the environment.

Compare the environmental effects of different inorganic and organic nutrient pollutants. [9 marks]

[Turn over]

[Turn over]

[Turn over]

15

Write an essay on ONE of the following topics.

11.1

Discuss how water resources may be managed to meet the demands of society but minimise the impacts on the environment. [25 marks]

OR

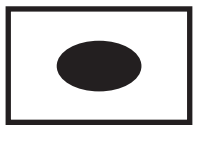
11.2

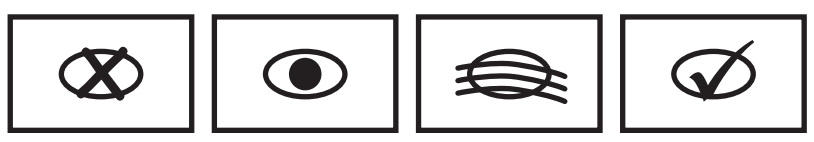
Discuss how mineral resources may be managed to meet the demands of society but minimise the impacts on the environment. [25 marks]

Shade the lozenge below to indicate which optional question you have answered.

Question 11 . 1 ⬭

Question 11 . 2 ⬭

CORRECT METHOD 

WRONG METHODS 

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[Turn over]

END OF QUESTIONS

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Additional page, if required. Write the question numbers in the left-hand margin.

Additional page, if required. Write the question numbers in the left-hand margin.

Additional page, if required. Write the question numbers in the left-hand margin.

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For Examiner's Use	
Question	Mark
1	
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