AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____
I declare this is my own work.

GCSE
COMBINED SCIENCE: SYNERGY

F

Foundation Tier Paper 4 Physical Sciences

Friday 13 June 2025 Morning Time allowed: 1 hour 45 minutes

Materials
For this paper you must have:
- a ruler
- a protractor
- a scientific calculator
- the periodic table (enclosed)
- the Physics Equations Sheet (enclosed).

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 in the spaces provided. Do not write outside the box around each page or 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.
- In all calculations, show clearly how you work out your answer.

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

Information
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

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0 1 Energy resources are either renewable or non-renewable.

0 1 . 1 What is meant by a 'renewable energy resource'?

[1 mark]

Tick (✓) **one** box.

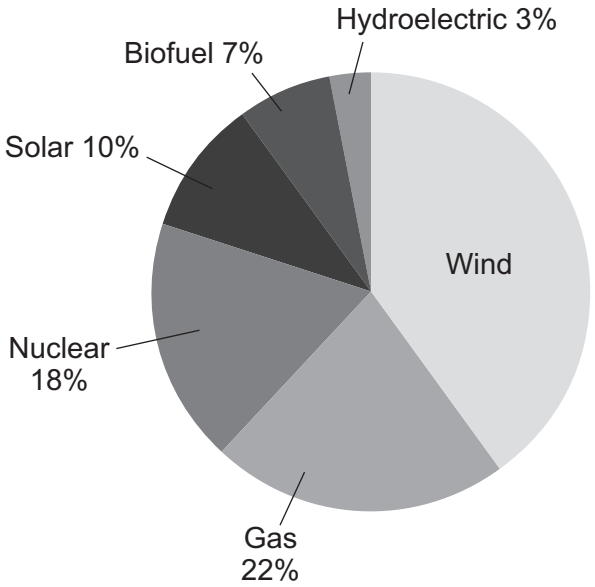
The energy resource can be burnt. ☐

The energy resource can be destroyed. ☐

The energy resource can be replenished. ☐

Figure 1 shows the percentage of electricity generated by different energy resources on one day in 2024.

Figure 1



Do not write outside the box

0 1 . 2 Calculate the percentage of electricity generated using wind.

Use **Figure 1**.

[2 marks]

_____

_____

_____

Percentage = _____ %

0 1 . 3 A wind turbine generated 200 000 W of electrical power in a time of 300 seconds.

Calculate the energy transferred by the wind turbine.

[2 marks]

Use the equation:

energy transferred = power × time

_____

_____

_____

Energy transferred = _____ J

Question 1 continues on the next page

Do not write outside the box

0 1 . 4 Why do wind turbines have a small environmental impact when generating electricity?

[1 mark]

Tick (✓) **one** box.

Wind turbines do not burn fuel to produce electricity. ☐

Wind turbines have no moving parts. ☐

Wind turbines occupy large areas of land. ☐

0 1 . 5 Which **two** of the following emit carbon dioxide when used to generate electricity?

[2 marks]

Tick (✓) **two** boxes.

Biofuel ☐

Gas ☐

Hydroelectric ☐

Nuclear ☐

Solar ☐

0 1 . 6 Give **one** environmental problem caused by carbon dioxide emissions.

[1 mark]

_____

9

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Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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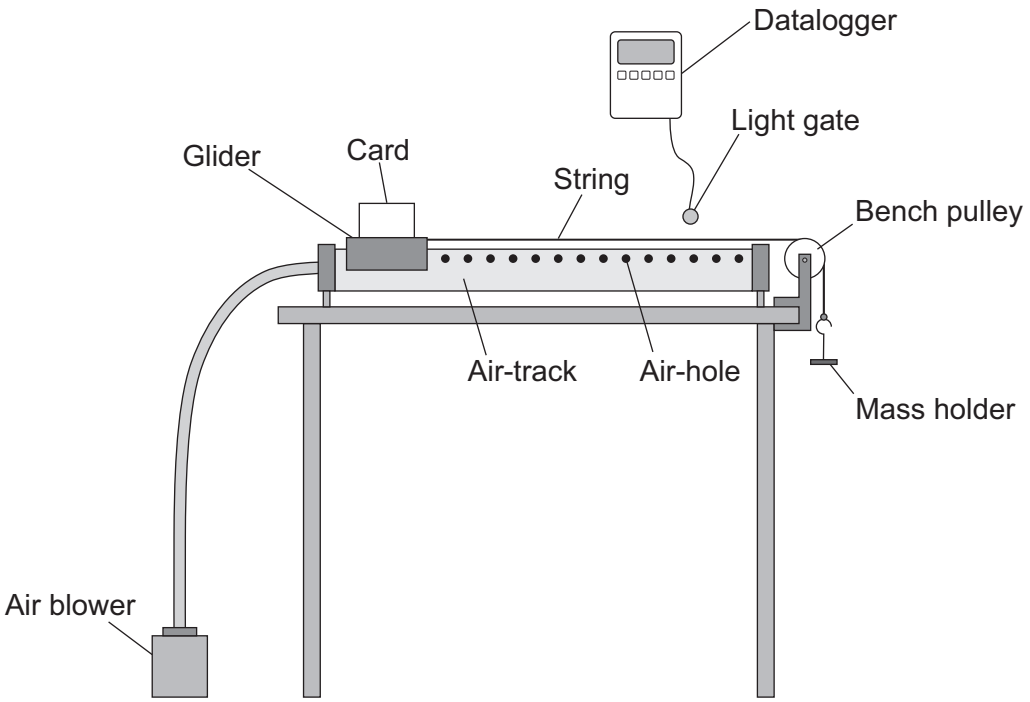
0 2 A student investigated how the acceleration of a glider on an air-track varies with the resultant force on the glider.

Figure 2 shows the apparatus used.

Figure 2



The air blower allows the glider to move along the air-track with almost no friction.

The resultant force acting on the glider is caused by the weight of the masses on the mass holder.

The datalogger calculates the velocity of the glider as the glider passes through the light gate.

This is the method used.

1. Release the glider from rest at the end of the air-track.
2. Record the velocity of the glider from the datalogger.
3. Repeat steps 1 and 2 two more times.
4. Record the resultant force acting on the glider.
5. Repeat steps 1 to 4 using different values of resultant force.

Do not write outside the box

0 2 . 1 The student should enter the length of the card into the datalogger so that the datalogger can calculate velocity.

Which measuring instrument should the student use to measure the length of the card?

[1 mark]

Tick (✓) **one** box.

Measuring cylinder ☐

Metre rule ☐

Newtonmeter ☐

Stopclock ☐

0 2 . 2 The light gate measures the time taken for the card to pass through the light gate as 0.043 seconds.

What is the resolution of the light gate?

[1 mark]

Tick (✓) **one** box.

0.001 s ☐ 0.003 s ☐ 0.043 s ☐

Question 2 continues on the next page

Do not write outside the box

0 2 . 3 **Table 1** shows the values for velocity when the resultant force was 0.50 N.

Table 1

Resultant force in N	Velocity in m/s			
	Test 1	**Test 2**	**Test 3**	**Mean**
0.50	2.22	2.32	2.18	2.24

What is the range of the values for velocity shown in **Table 1**?

[1 mark]

From _____ m/s to _____ m/s

0 2 . 4 The glider accelerated from rest for a distance of 0.98 m.

Calculate the acceleration of the glider when the velocity was 2.24 m/s.

[2 marks]

Use the equation:

$$\text{acceleration} = \frac{(\text{velocity})^2}{(2 \times \text{distance})}$$

_____

_____

_____

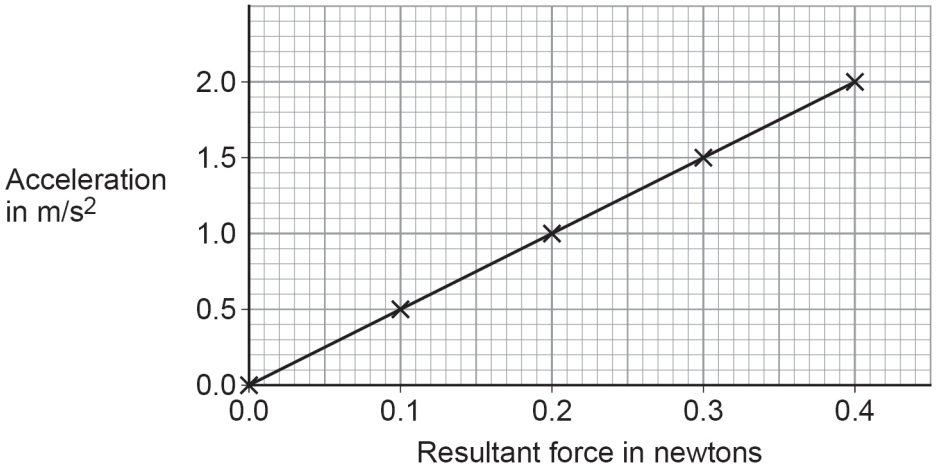
Acceleration = _____ m/s^2

Do not write outside the box

The student plotted a graph of the acceleration of the glider against the resultant force.

Figure 3 shows some of the results.

Figure 3



The student concluded:

‘The acceleration is directly proportional to the resultant force because the graph has a constant gradient.’

0 2 . 5 What other feature on a graph is needed to show a directly proportional relationship?

[1 mark]

Tick (✓) **one** box.

The line should curve upwards. ☐

The line should have a negative gradient. ☐

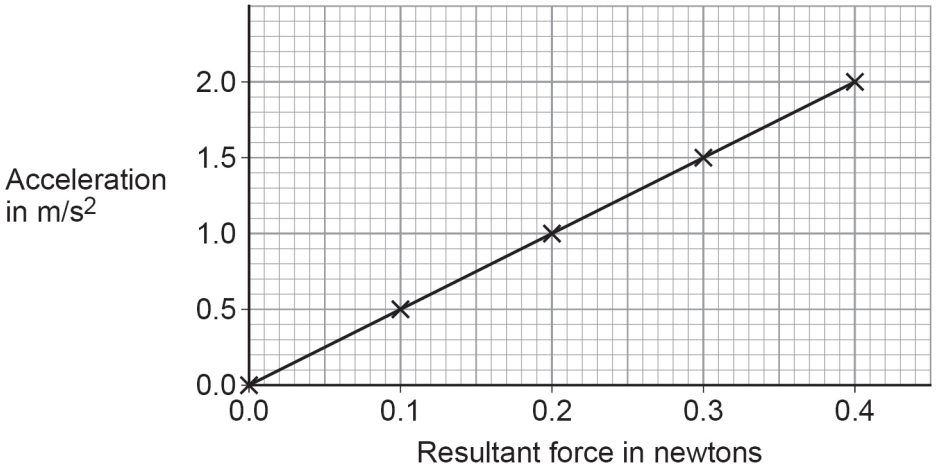
The line should pass through the origin. ☐

Question 2 continues on the next page

Do not write outside the box

0 2 . 6 **Figure 3** is repeated below.

Figure 3



Calculate the gradient of the line in **Figure 3**.

Use the equation:

$$\text{gradient} = \frac{\text{change in acceleration}}{\text{change in resultant force}}$$

[2 marks]

_____

_____

_____

Gradient = _____

8

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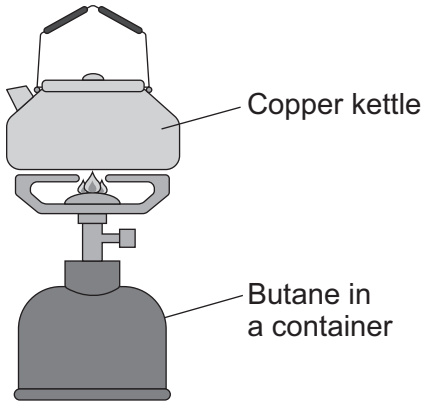
0 3 Alkanes are used as fuels.

Butane is an alkane.

Figure 4 shows butane being used to heat a copper kettle.

Figure 4



0 3 . 1 The use of butane as a fuel involves a combustion reaction.

What gas in the air does butane react with during combustion?

[1 mark]

_____

0 3 . 2 Why is copper a suitable material for a kettle?

[1 mark]

Tick (✓) **one** box.

Copper can be shaped. ☐

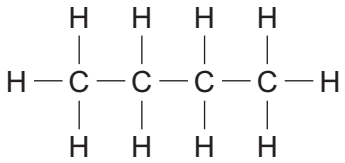
Copper has a low melting point. ☐

Copper reacts with water. ☐

Do not write outside the box

Figure 5 represents a butane molecule.

Figure 5



0 3 . 3 Determine the **empirical** formula of butane.

You should determine:

- the number of carbon atoms and hydrogen atoms in a molecule of butane
- the simplest ratio of carbon atoms to hydrogen atoms
- the empirical formula.

Use **Figure 5**.

[4 marks]

Number of carbon atoms _____

Number of hydrogen atoms _____

_____

_____

Simplest ratio, C : H = _____ : _____

Empirical formula = C ____ H ____

Do not write outside the box

0 3 . 4 What is the type of bonding in a butane molecule?

Use **Figure 5**.

[1 mark]

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

0 3 . 5 What type of structure does butane have?

Use **Figure 5**.

[1 mark]

Tick (✓) **one** box.

Giant structure ☐

Polymer ☐

Small molecule ☐

Question 3 continues on the next page

Do not write outside the box

0 3 . 6 **Table 2** shows the melting points and boiling points of three alkanes.

Table 2

Alkane	Melting point in °C	Boiling point in °C
Ethane	−183	−89
Propane	−190	−42
Butane	−138	−1

Which alkane is a liquid at −185 °C?

[1 mark]

Tick (✓) **one** box.

Ethane ☐

Propane ☐

Butane ☐

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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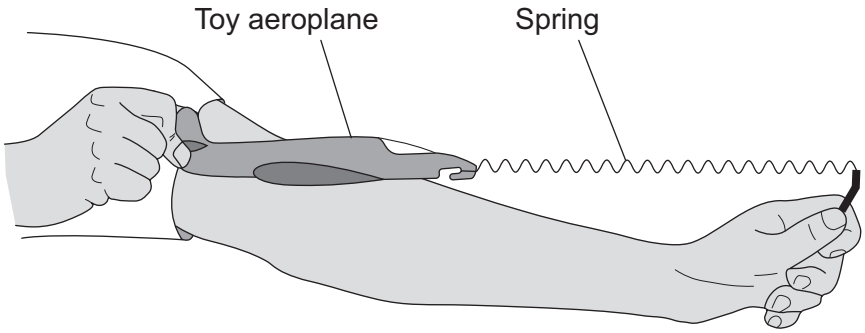
0 4 **Figure 6** shows a student about to launch a toy aeroplane horizontally.

Figure 6



The student pulls on the aeroplane to stretch the spring.

The student then releases the aeroplane and the spring gets shorter.

0 4 . 1 How does the elastic potential energy of the spring change just after the aeroplane is released?

[1 mark]

Tick (✓) **one** box.

The elastic potential energy decreases. ☐

The elastic potential energy stays the same. ☐

The elastic potential energy increases. ☐

Do not write outside the box

0 4 . 2 How does the kinetic energy of the aeroplane change just after the aeroplane is released?

[1 mark]

Tick (✓) **one** box.

The kinetic energy decreases. ☐

The kinetic energy stays the same. ☐

The kinetic energy increases. ☐

0 4 . 3 Complete the sentence.

Choose the answer from the box.

[1 mark]

conserved	**created**	**destroyed**

The maximum kinetic energy of the aeroplane is the same as the maximum elastic potential energy of the spring.

This is because energy is _____.

Question 4 continues on the next page

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ANSWER IN THE SPACES PROVIDED

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0 4 . 4 As the aeroplane is launched, the mean force of the spring on the aeroplane is 8.0 N.

The distance moved by the aeroplane during the launch is 0.25 m.

Calculate the work done on the aeroplane.

[3 marks]

Use the equation:

work done = force × distance

Choose the unit from the box.

joules	**metres**	**newtons**

_____

_____

_____

_____

Work done = _____ Unit _____

Question 4 continues on the next page

Do not write outside the box

After launching, the aeroplane detached from the spring and glided until it reached the ground.

Table 3 shows how the horizontal distance travelled varied with the extension of the spring when the aeroplane was released.

Table 3

Extension of spring in metres	Horizontal distance travelled in metres
0.00	0.00
0.20	0.90
0.40	1.80
0.60	2.70
0.80	3.60

Do not write outside the box

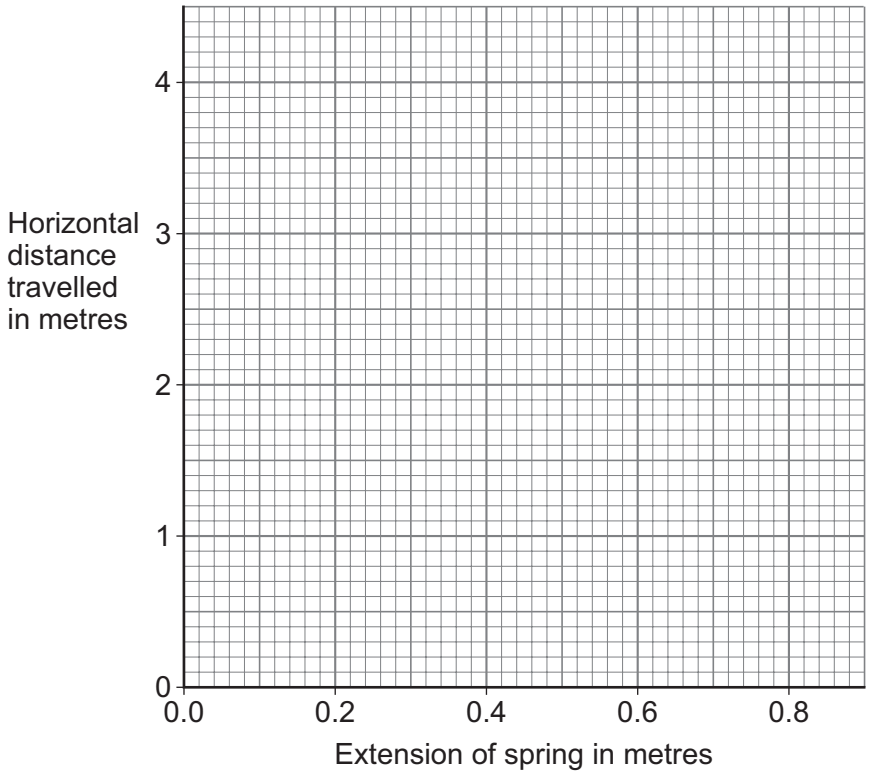
0 4 . 5 Complete **Figure 7**.

You should:

- plot the data from **Table 3** on **Figure 7**
- draw a line of best fit.

[3 marks]

Figure 7



0 4 . 6 Complete the sentence.

[1 mark]

When the extension of the spring increases, the horizontal distance travelled by the aeroplane _____.

Question 4 continues on the next page

Do not write outside the box

0 4 . 7 Which **two** changes would make the aeroplane fly a greater horizontal distance?

[2 marks]

Tick (✓) **two** boxes.

Decrease the length of the wings of the aeroplane. ☐

Increase the launch speed of the aeroplane. ☐

Increase the mass of the aeroplane. ☐

Launch the aeroplane vertically upwards. ☐

Make the aeroplane more streamlined. ☐

12

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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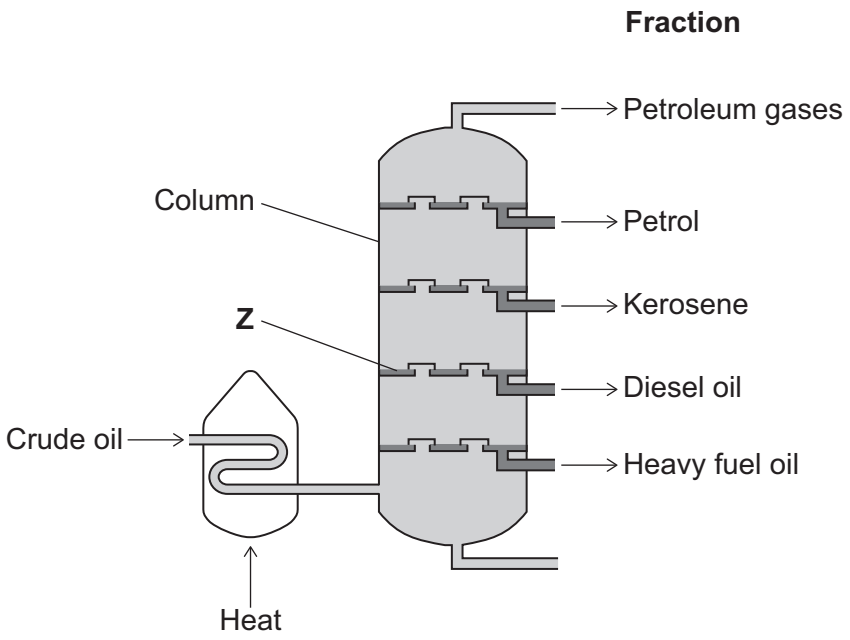
0 5 Hydrocarbons in crude oil are separated into fractions using fractional distillation.

Figure 8 shows a fractional distillation column.

Figure 8



0 5 . 1 Complete the sentence.

Choose the answer from the box.

[1 mark]

cooler	**the same**	**warmer**

Compared with the bottom of the column, the temperature at the top of the column is _____.

Do not write outside the box

0 5 . 2 What is the name of the process that produces the diesel oil fraction at **Z** on **Figure 8**?

[1 mark]

Tick (✓) **one** box.

Condensing ☐

Freezing ☐

Melting ☐

Different hydrocarbons have different-sized molecules.

0 5 . 3 Complete the sentence.

Choose the answer from the box.

[1 mark]

decreases	**stays the same**	**increases**

As the size of the hydrocarbon molecules increases, the boiling point of the hydrocarbon _____.

0 5 . 4 Complete the sentence.

Choose the answer from the box.

[1 mark]

decreases	**stays the same**	**increases**

As the size of the hydrocarbon molecules increases, the flammability of the hydrocarbon _____.

Do not write outside the box

0 5 . 5 Crude oil contains different percentages of each fraction.

Table 4 shows information about petrol and heavy fuel oil.

Table 4

Fraction	**Percentage (%) supplied by fractional distillation**	**Percentage (%) needed to meet demand**	**Number of carbon atoms in a molecule**
Petrol	34	45	5 to 10
Heavy fuel oil	31	23	21 to 70

The supply of petrol is not enough to meet the demand for petrol.

The additional petrol needed can be produced by cracking other fractions.

Cracking breaks down larger molecules into smaller molecules.

Give **two** reasons why heavy fuel oil is a suitable fraction to be cracked to produce petrol.

[2 marks]

1 _____

_____

2 _____

_____

Do not write outside the box

0 5 . 6 The products of cracking include another type of hydrocarbon called alkenes.

Small alkene molecules can join together to produce long-chain molecules.

What type of reaction produces long-chain molecules?

[1 mark]

Tick (✓) **one** box.

Decomposition ☐

Oxidation ☐

Polymerisation ☐

Question 5 continues on the next page

Do not write outside the box

Plastics are produced from alkenes.

Drinks can be sold in plastic bottles or glass bottles.

0 5 . 7 **Table 5** shows information about some plastic bottles and some glass bottles.

Table 5

	Volume of one bottle in cm^3	**Mass of one bottle in grams**
Plastic	250	20
Glass	250	270

Explain why less energy is used to transport the same volume of liquid in plastic bottles than in glass bottles.

[2 marks]

_____

_____

_____

_____

0 5 . 8 Some plastic bottles are disposed of as waste in landfill sites.

Suggest **two** ways that people can reduce the environmental impact of plastic bottles.

[2 marks]

1 _____

_____

2 _____

_____

11

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 6 A student investigated how the current in a filament lamp varies with the potential difference across the lamp.

Figure 9 shows the circuit used.

Figure 9

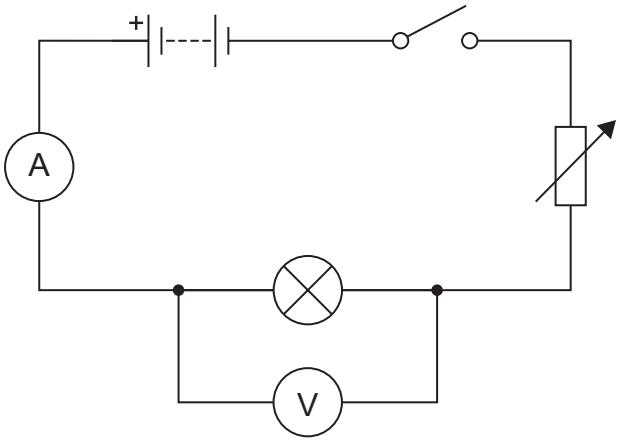
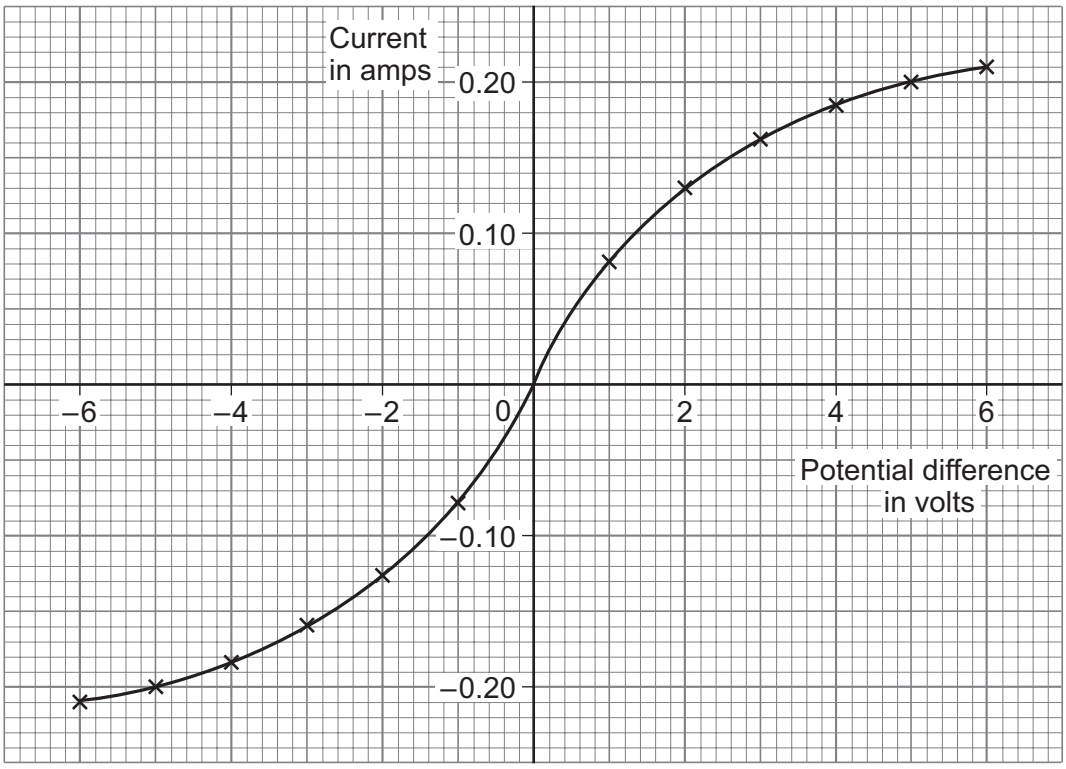


Figure 10 shows the results.

Figure 10



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0 6 . 1 Describe a method the student could have used to obtain the results in **Figure 10**.

[6 marks]

Extra space

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 How does an increase in the temperature of a filament lamp affect the resistance of the filament lamp?

[1 mark]

Tick (✓) **one** box.

The resistance of the filament lamp decreases. ☐

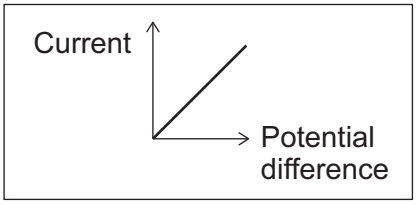
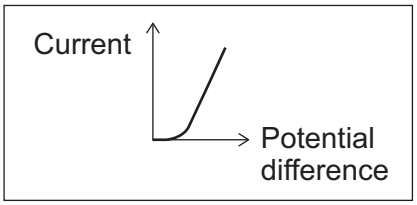
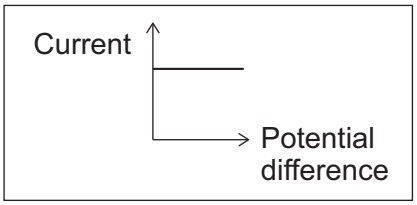
The resistance of the filament lamp stays the same. ☐

The resistance of the filament lamp increases. ☐

0 6 . 3 The results for other components are different from the filament lamp.

Draw **one** line from each component to the correct graph.

[2 marks]

Component	**Graph**
Diode	
Resistor at constant temperature	
	

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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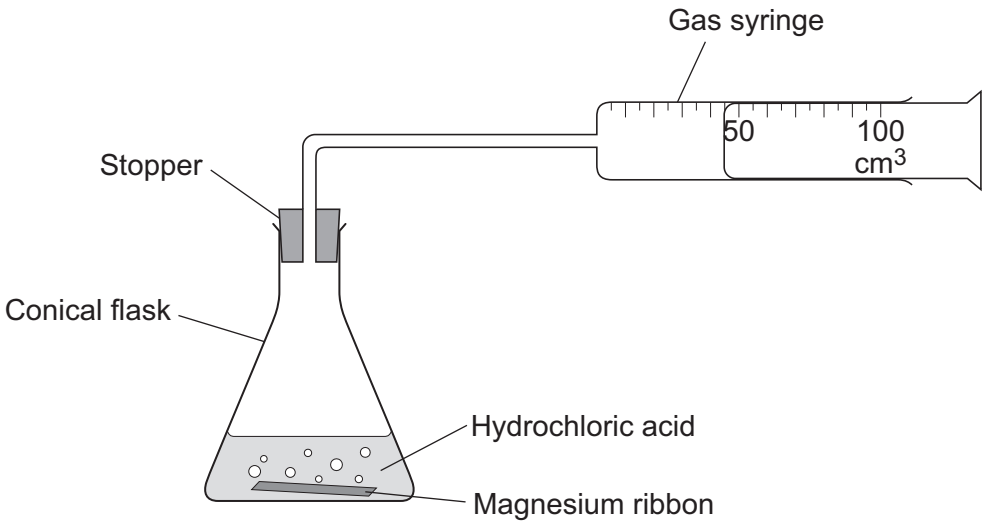
0 7 A student investigated how the surface area of magnesium affects the rate of the reaction between magnesium and hydrochloric acid.

Figure 11 shows the apparatus.

Figure 11



This is the method used.

1. Add 50 cm^3 of hydrochloric acid to the conical flask.
2. Add 0.05 g of magnesium ribbon to the hydrochloric acid.
3. Insert the stopper into the conical flask as quickly as possible.
4. Start a stopclock.
5. Record the volume of gas collected in the gas syringe every 20 seconds for 100 seconds.
6. Repeat steps 1 to 5 with 0.05 g of magnesium powder.

Do not write outside the box

0 7 . 1 Magnesium reacts with hydrochloric acid to produce magnesium chloride and hydrogen.

Balance the equation for the reaction.

[1 mark]

$$Mg + ____ HCl \longrightarrow MgCl_2 + H_2$$

0 7 . 2 What was the independent variable in the investigation?

[1 mark]

Tick (✓) **one** box.

Surface area of magnesium ☐

Time interval ☐

Volume of hydrochloric acid ☐

0 7 . 3 Why was the stopper inserted into the conical flask as quickly as possible in step 3?

[1 mark]

_____

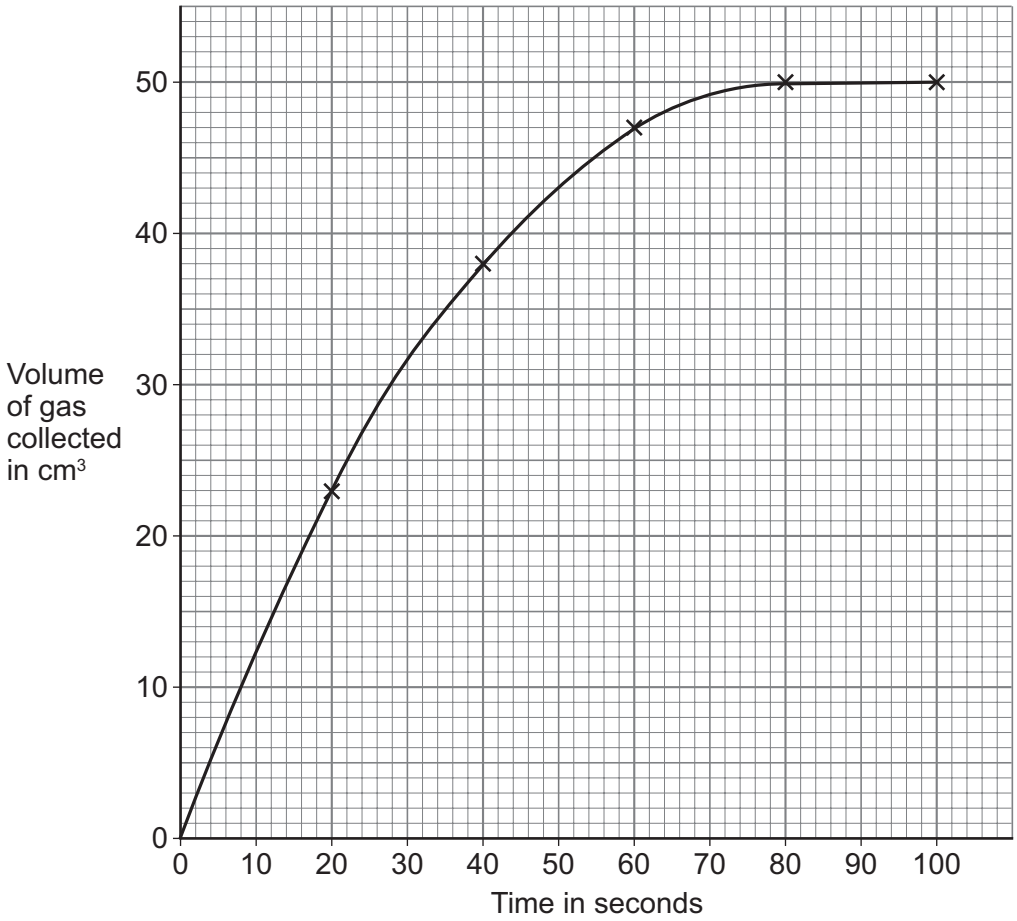
_____

Question 7 continues on the next page

Do not write outside the box

Figure 12 shows the results for magnesium ribbon.

Figure 12



Do not write outside the box

0 7 . 4 Determine the mean rate of reaction between 20 seconds and 60 seconds.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{volume of gas collected}}{\text{time taken}}$$

Use data from **Figure 12**.

Choose the unit from the box.

[5 marks]

cm^3/s	**g/s**	**s/cm^3**	**s/g**

Volume of gas collected = _____ cm^3

Time taken = _____ s

Mean rate of reaction = _____ Unit _____

0 7 . 5 Explain the trend for the volume of gas collected after 80 seconds.

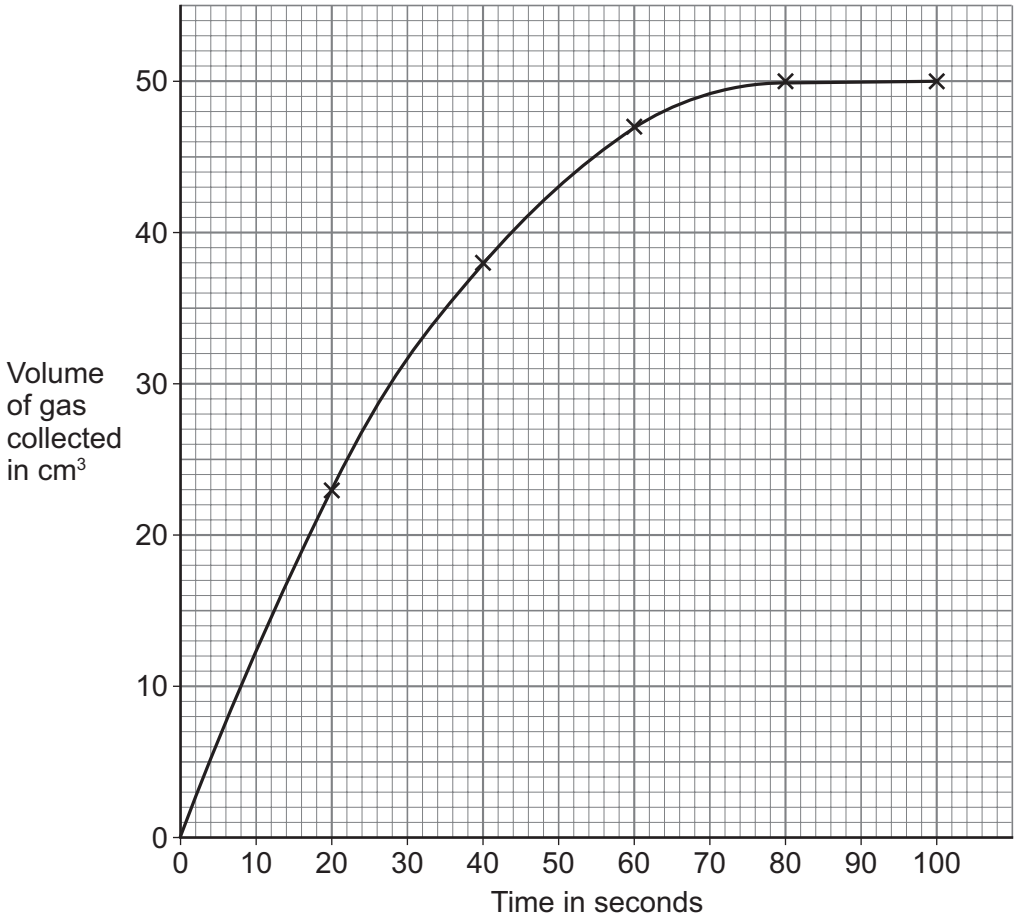
Use **Figure 12**.

[2 marks]

Do not write outside the box

0 7 . 6 **Figure 13** shows the results for magnesium ribbon.

Figure 13



The student then used 0.05 g of magnesium powder instead of 0.05 g of magnesium ribbon.

Draw a line on **Figure 13** to show the expected results for the magnesium powder.

[2 marks]

12

Do not write outside the box

Turn over for the next question

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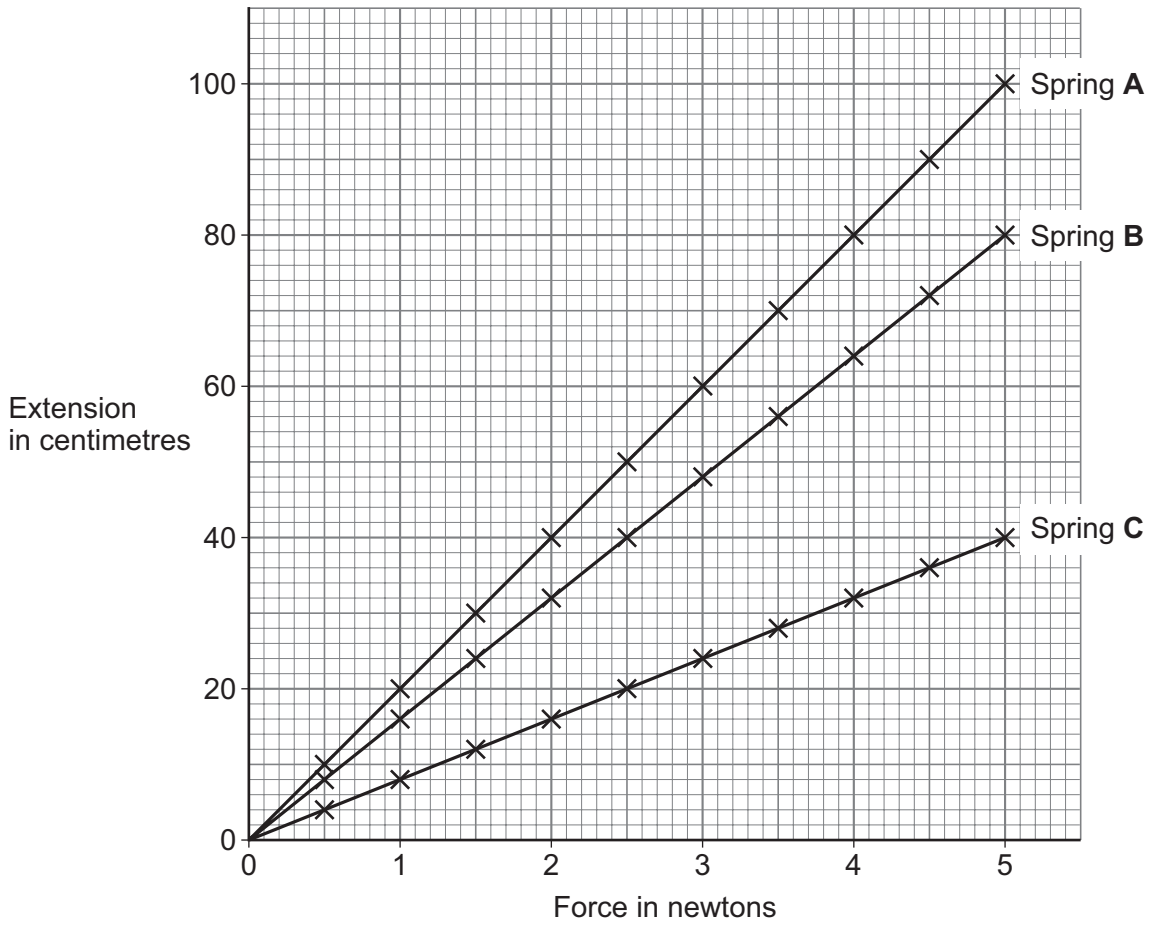
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 8 **Figure 14** shows how the extension of three different springs varies with the force applied to each spring.

Figure 14



0 8 . 1 Describe the relationship between force and extension for spring **A**.

[2 marks]

Do not write outside the box

0 8 . 2 Which spring in **Figure 14** has the greatest spring constant?

Give a reason for your answer.

[2 marks]

Tick (✓) **one** box.

Spring **A** ☐ Spring **B** ☐ Spring **C** ☐

Reason _____

_____

Question 8 continues on the next page

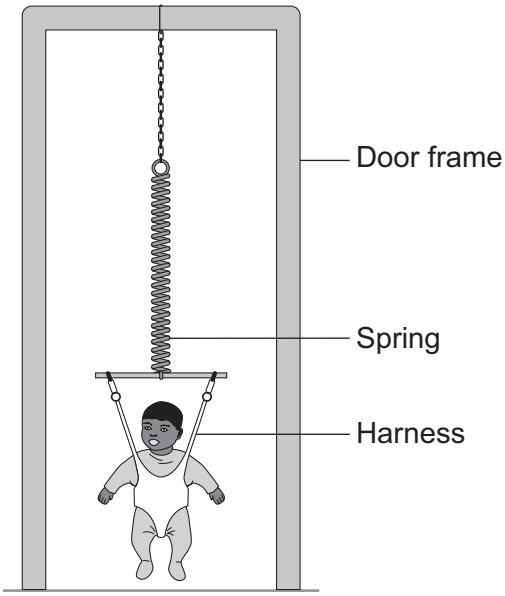
Do not write outside the box

Figure 15 shows a baby in a ‘baby-bouncer’.

The baby sits in a harness which is held by a spring.

When the baby jumps, the baby bounces up and down.

Figure 15



Do not write outside the box

0 8 . 3 The spring of the baby-bouncer is extended by 0.60 m.

The elastic potential energy stored by the spring is 75.6 J.

Calculate the spring constant of the spring.

Use the Physics Equations Sheet.

Choose the unit from the box.

N m	**N/m**	**N/m^2**

[4 marks]

Spring constant = _____ Unit _____

0 8 . 4 The spring does **not** extend past the limit of proportionality when the baby is in the baby-bouncer.

How does the work done to stretch the spring compare with the elastic potential energy stored in the spring?

[1 mark]

Tick (✓) **one** box.

Work done is less than elastic potential energy stored. ☐

Work done is equal to elastic potential energy stored. ☐

Work done is greater than elastic potential energy stored. ☐

9

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0 9 This question is about acids and alkalis.

Universal indicator is used to measure the pH of solutions.

Figure 16 shows the colours of universal indicator at different pH values.

Figure 16

Colour	pH value
Red	1 2 3
Orange	4 5
Green	6 7 8
Blue	9 10 11
Purple	12 13 14

A student added universal indicator to nitric acid in a beaker.

The student added drops of potassium hydroxide solution to the nitric acid until pH 7 was reached.

Do not write outside the box

0 9 . 1 The student could **not** be sure that the pH of the mixture was 7

Give **one** reason why.

Use **Figure 16**.

[1 mark]

_____

_____

0 9 . 2 Name a piece of equipment that could be used to give a more accurate measurement of pH.

[1 mark]

_____

0 9 . 3 Name the type of reaction when potassium hydroxide solution reacts with nitric acid.

[1 mark]

_____

0 9 . 4 The formula of nitric acid is HNO_3

Calculate the relative formula mass (M_r) of nitric acid.

Relative atomic masses (A_r): H = 1 N = 14 O = 16

[2 marks]

_____

_____

_____

Relative formula mass = _____

Turn over ▶

Do not write outside the box

0 9 . 5 Potassium hydroxide is an alkali.

Which ion do all alkalis contain?

[1 mark]

Tick (✓) **one** box.

H^+ ☐ K^+ ☐ O^{2-} ☐ OH^- ☐

0 9 . 6 The concentration of the solution of potassium hydroxide was 5.6 g/dm^3.

Calculate the mass of potassium hydroxide in 5 cm^3 of the solution.

1 dm^3 = 1000 cm^3

[3 marks]

_____

_____

_____

_____

_____

Mass = _____ g

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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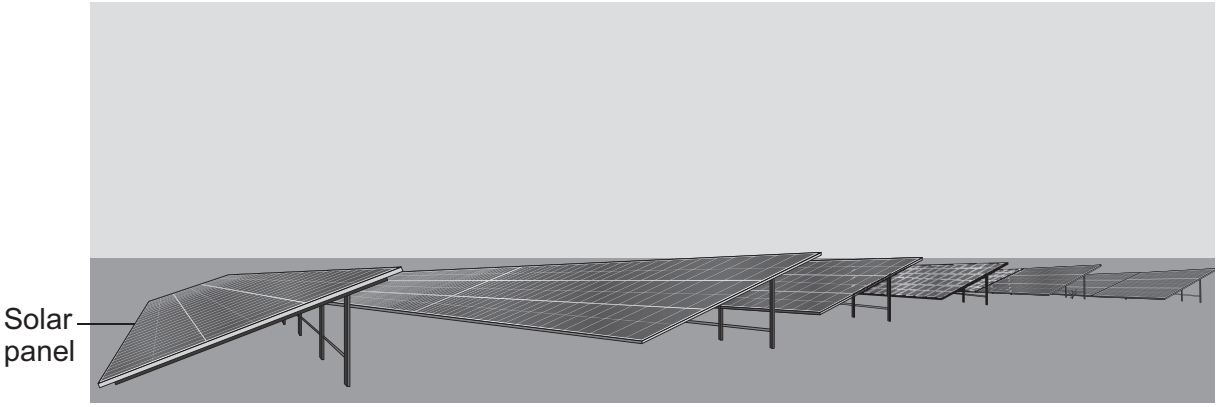
1 0 **Figure 17** shows solar panels in a field on a small remote island.

The solar panels provide electricity to a small village.

Figure 17



1 0 . 1 On a sunny day, the power input to the solar panels is 468 000 W.

The total area of the solar panels is 720 m^2.

Calculate the power input to an area of 1 m^2 of the solar panels.

[2 marks]

_____

_____

_____

Power input to 1 m^2 = _____ W

Do not write outside the box

Use the Physics Equations Sheet to answer questions **10.2** and **10.3**.

1 0 . 2 Which equation links efficiency, total power input and useful power output?

[1 mark]

Tick (✓) **one** box.

efficiency = $\frac{\text{useful power output}}{\text{total power input}}$ ☐

efficiency = $\frac{\text{total power input}}{\text{useful power output}}$ ☐

efficiency = total power input × useful power output ☐

1 0 . 3 On a cloudy day, the total power input to the solar panels is 250 000 W.

The efficiency of the solar panels is 0.20

Calculate the useful power output of the solar panels.

[3 marks]

_____

_____

_____

_____

_____

Useful power output = _____ W

Question 10 continues on the next page

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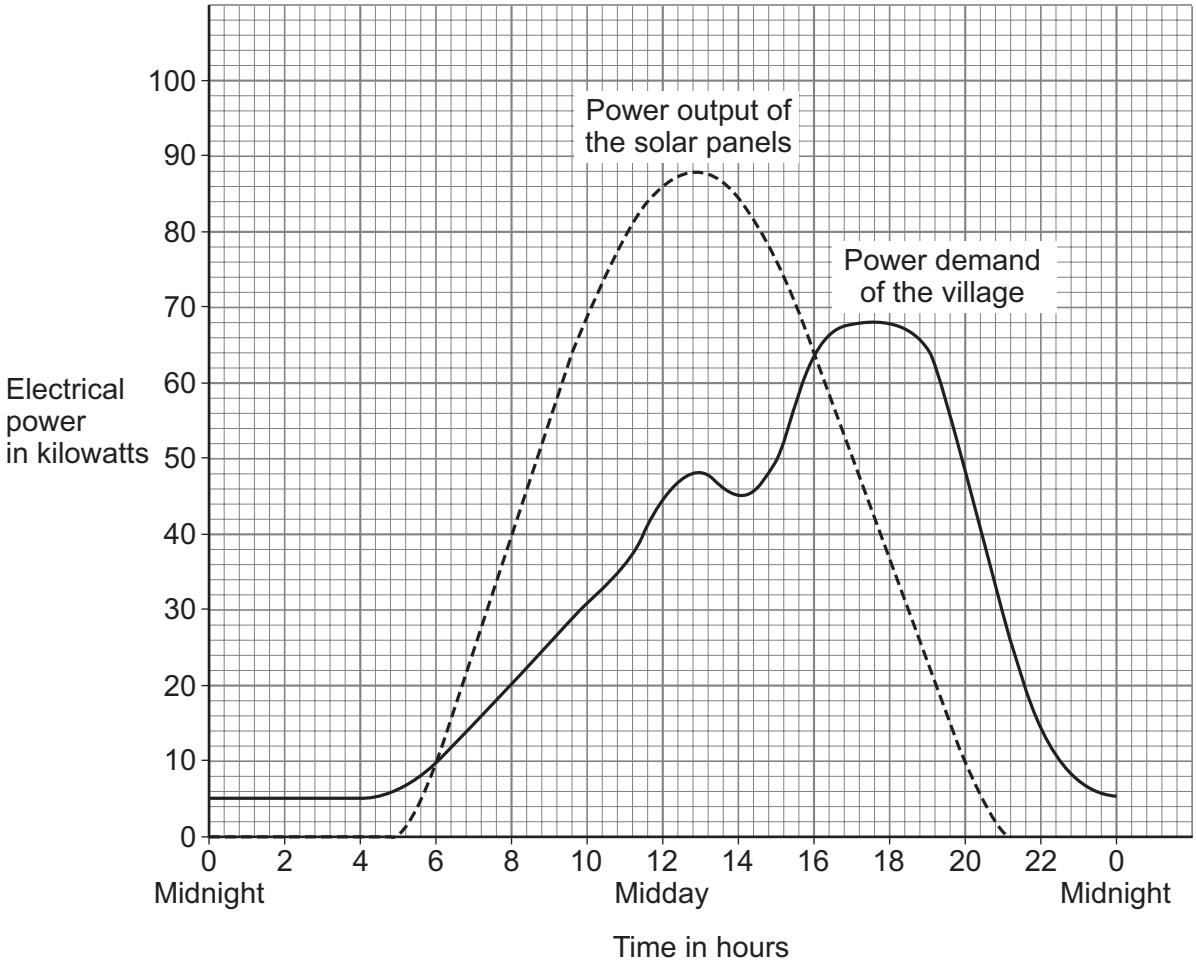
Figure 18 shows during one day:

- the electrical power demand of the village
- the electrical power output of the solar panels.

Figure 18



1 0 . 4 Determine for how much time the electrical power demand was greater than the electrical power output.

[2 marks]

_____

_____

Time = _____ hours

Do not write outside the box

1 0 . 5 A large battery is used to store excess energy from the solar panels.

The battery transfers power to the village when the power output of the solar panels is less than the demand.

The village is **not** connected to the National Grid.

Explain why the village needs the solar panels **and** the battery for a continuous electricity supply.

Use information from **Figure 18**.

[4 marks]

_____

_____

_____

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12

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