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

H

Higher Tier Paper 4 Physical Sciences

Tuesday 13 June 2023 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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ANSWER IN THE SPACES PROVIDED

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0 1 This question is about hydrocarbon fuels.

The **complete** combustion of a hydrocarbon fuel produces carbon dioxide and one other product.

0 1 . 1 Name the other product of the **complete** combustion of a hydrocarbon fuel.

Do **not** refer to carbon dioxide.

[1 mark]

_____

0 1 . 2 Describe the test for carbon dioxide.

Give the result if carbon dioxide is present.

[2 marks]

Test _____

_____

Result _____

_____

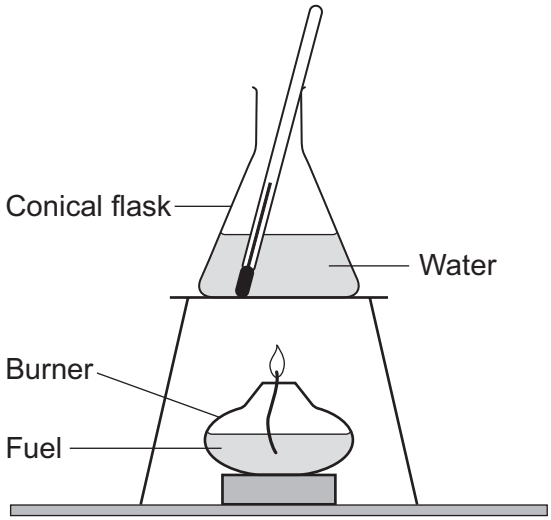
Question 1 continues on the next page

The combustion of hydrocarbon fuels releases energy.

A student investigated the energy released by three different fuels **A**, **B** and **C**.

Figure 1 shows the apparatus.

Figure 1



This is part of the method used.

1. Put fuel **A** in the burner.
2. Pour 100 cm^3 of water into the conical flask.
3. Record the temperature of the water.
4. Light the fuel and heat the water for 5 minutes.
5. Record the final temperature of the water.
6. Repeat steps 1 to 5 using fuel **B** and then using fuel **C**.

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0 1 . 3 The student also determined the mass of fuel burnt.

Describe how the student could determine the mass of fuel burnt.

[2 marks]

0 1 . 4 Give **one** control variable in the investigation.

[1 mark]

0 1 . 5 **Table 1** shows the results.

Table 1

Fuel	Mass of fuel burnt in grams	Temperature increase of water in ˚C
A	1.72	40
B	1.65	45
C	1.23	50

Explain how **Table 1** shows that fuel **C** released the most energy per gram of fuel.

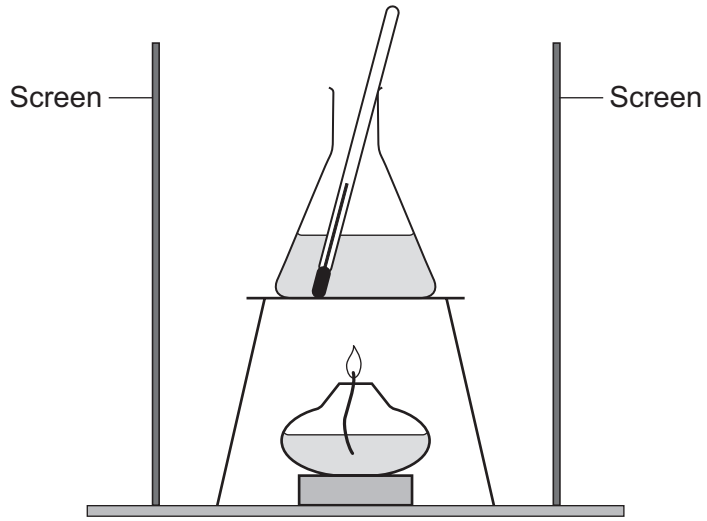
[2 marks]

Question 1 continues on the next page

0 1 . 6 The student repeated the investigation with screens around the apparatus.

Figure 2 shows the apparatus with screens.

Figure 2



Give **one** reason why putting screens around the apparatus could improve the accuracy of the investigation.

[1 mark]

0 1 . 7 How would stirring the water improve the accuracy of the investigation?

[1 mark]

10

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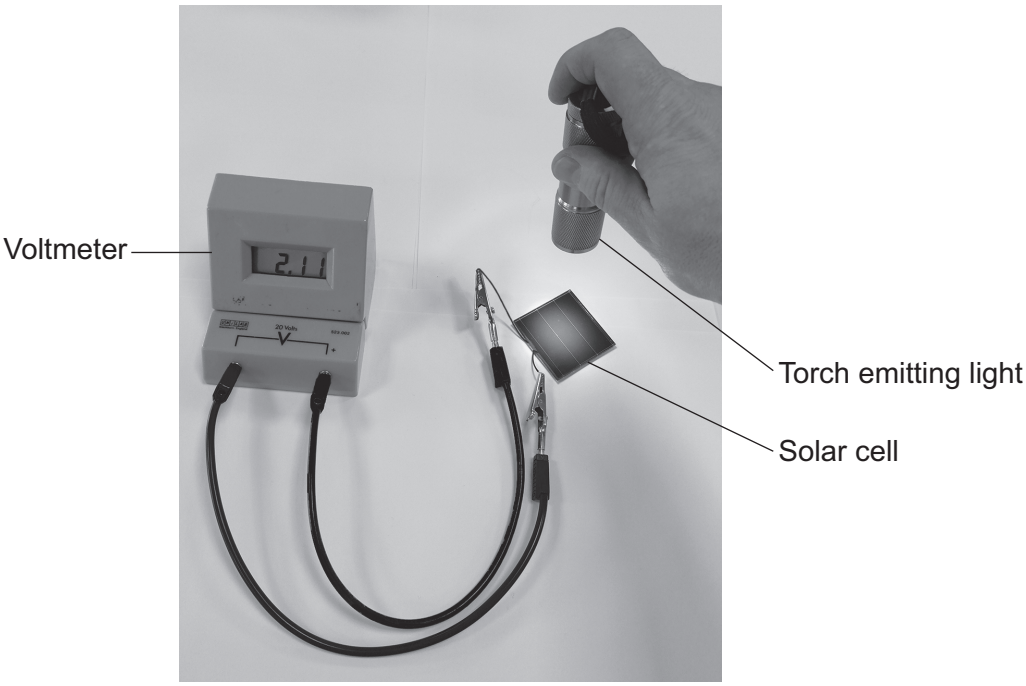
ANSWER IN THE SPACES PROVIDED

0 2 A solar cell generates a potential difference when light shines on its surface.

A student investigated how the potential difference varied with the light intensity at the surface of the solar cell.

Figure 3 shows some of the equipment used by the student.

Figure 3

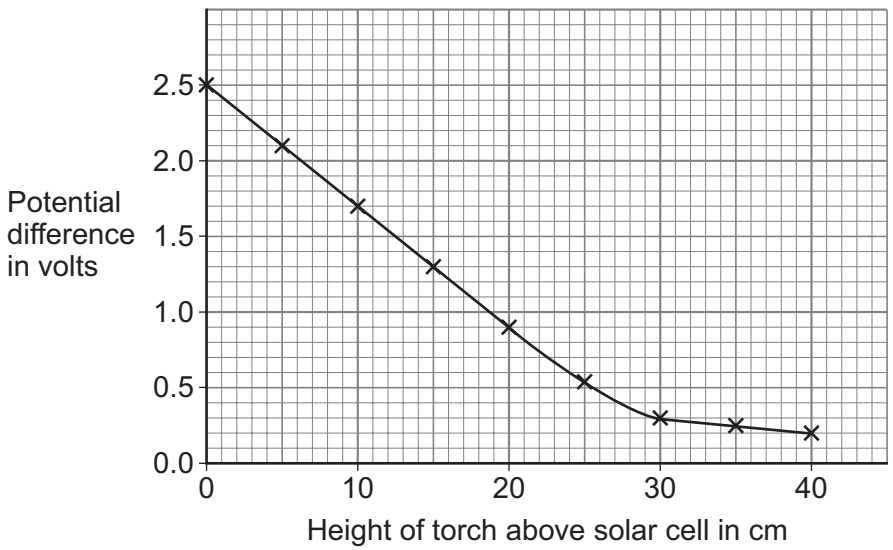


The voltmeter displayed the potential difference generated by the solar cell.

The student varied the light intensity by changing the height of the torch above the solar cell.

Figure 4 shows the results.

Figure 4



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0 2 . 1 Describe a method the student could have used to obtain the results shown in **Figure 4**.

[6 marks]

Question 2 continues on the next page

The circuit symbol for a solar cell is:

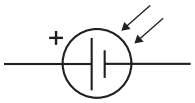


Figure 5 shows the solar cell in a circuit with an LED and a resistor.

Figure 5

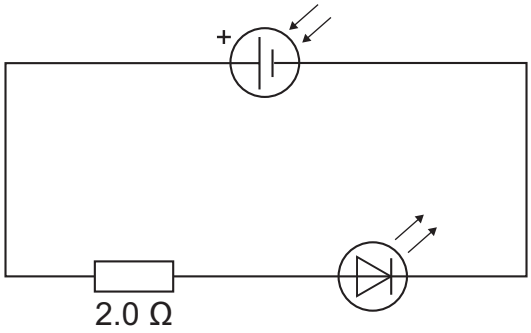
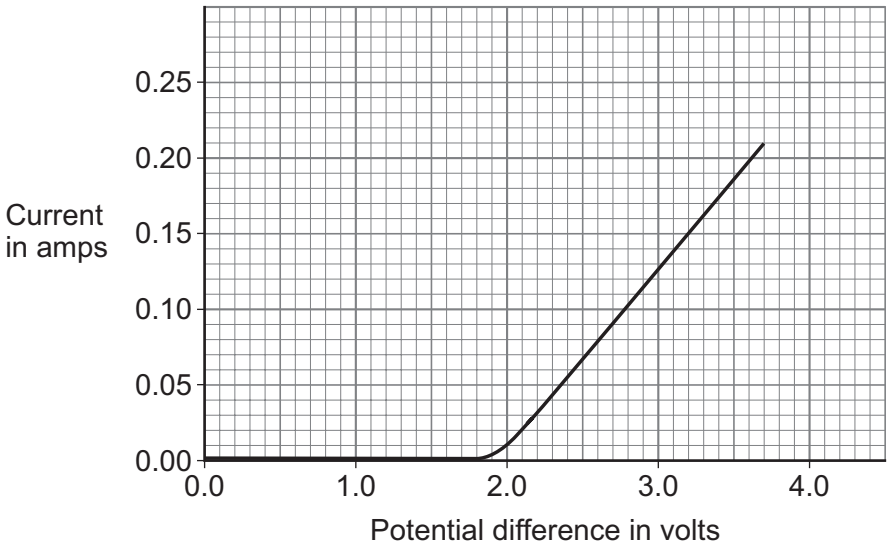


Figure 6 shows how the current in the LED varies with the potential difference across the LED.

Figure 6



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0 2 . 2 What is the range of potential difference values for which the LED emits light in **Figure 6**?

[1 mark]

Range of values = _____ to _____ V

Use the Physics Equations Sheet to answer questions **02.3** and **02.4**.

0 2 . 3 Which equation links current (I), potential difference (V) and resistance (R)?

[1 mark]

Tick (✓) **one** box.

$V = I R$ ☐ $V = I^2 R$ ☐ $V = I R^2$ ☐ $V = \frac{I}{R}$ ☐

0 2 . 4 Determine the resistance of the LED when the potential difference across the LED is 2.7 V.

Use **Figure 6**.

[4 marks]

_____

_____

_____

_____

Resistance = _____ Ω

0 2 . 5 Describe how the resistance of the LED varies as the p.d. increases from 0 V to 3.7 V.

Use data from **Figure 6**.

[2 marks]

_____

_____

_____

14

0 3 **Figure 7** shows two different designs of wind turbine.

Figure 7

Three-blade wind turbine

Bladeless wind turbine

To generate electricity, the three-blade wind turbine rotates about an axis.

To generate electricity, the bladeless wind turbine oscillates from side to side.

Table 2 gives information about the two designs.

Table 2

Feature	Three-blade turbine	Bladeless turbine
Lubrication needed	Yes	No
Maintenance costs	High	Low
Noise level	High	Low
Power output	High	Low
Risk to flying birds	Yes	No

Do not write outside the box

0 3 . 1 Which feature of the three-blade turbine is an advantage compared with the bladeless turbine?

Use **Table 2**.

Give a reason for your answer.

[2 marks]

Feature _____

Reason _____

_____

Question 3 continues on the next page

To generate electricity, the bladeless wind turbine oscillates from side to side.

Figure 8 shows the direction of the oscillations of the bladeless wind turbine.

Figure 8

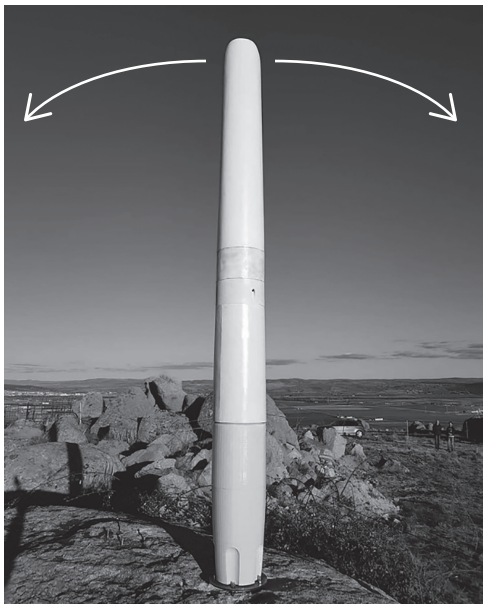
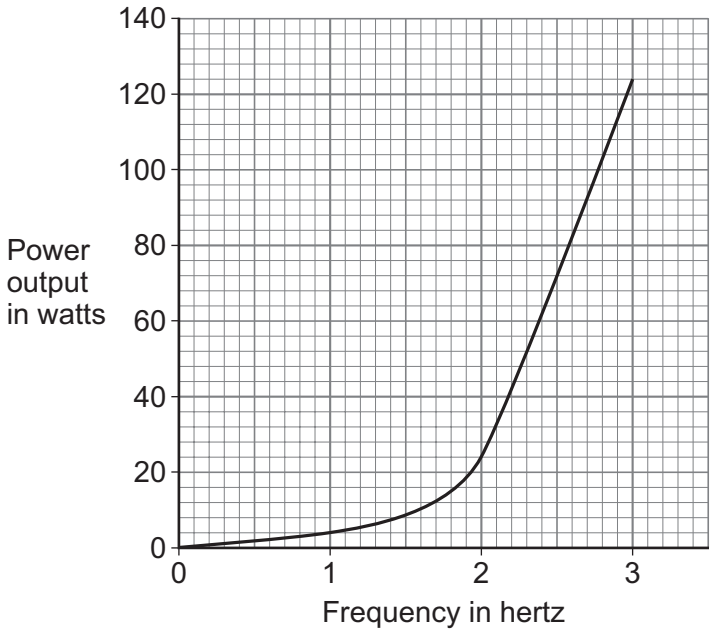


Figure 9 shows how the power output of the bladeless turbine varies with the frequency of the oscillation.

Figure 9



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0 3 . 2 Describe how the power output of the bladeless turbine varies with frequency.

[2 marks]

Question 3 continues on the next page

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The energy from wind turbines can be used to recharge a battery.

Use the Physics Equations Sheet to answer questions **03.3** and **03.4**.

0 3 . 3 Which equation links charge flow (Q), current (I) and time (t)?

[1 mark]

Tick (✓) **one** box.

$Q = I\,t$ ☐

$Q = I\,t^2$ ☐

$Q = I^2\,t$ ☐

$Q = \frac{I}{t}$ ☐

0 3 . 4 To fully recharge the battery, a charge of 216 000 C needs to flow through the battery.

The current in the battery is 5.0 A.

Calculate the time taken to fully recharge the battery.

Give the unit.

[4 marks]

Time taken = _____ Unit _____

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 This question is about metal extraction.

Copper compounds can be extracted from low-grade copper ores using:

- plants
- bacteria.

0 4 . 1 Name the process that uses plants to extract copper compounds from low-grade copper ores.

[1 mark]

_____

0 4 . 2 Name the process that uses bacteria to extract copper compounds from low-grade copper ores.

[1 mark]

_____

0 4 . 3 Why are processes using plants and bacteria now used to extract copper compounds from low-grade copper ores?

[1 mark]

_____

_____

0 4 . 4 Give **one** advantage of extracting copper compounds using plants and bacteria rather than using traditional methods.

[1 mark]

_____

_____

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Aluminium is extracted by the electrolysis of a molten mixture of aluminium oxide and cryolite.

0 4 . 5 Explain why the electrolyte used is a mixture of aluminium oxide and cryolite.

Do **not** refer to cost in your answer.

[2 marks]

0 4 . 6 Oxygen is produced at the positive electrodes.

Explain why the positive electrodes must be continually replaced.

[3 marks]

9

Turn over for the next question

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0 5 **Figure 10** shows a karate expert breaking a wooden board with one hand.

Figure 10

0 5 . 1 When the hand hits the wooden board, the initial velocity of the hand is 7.5 m/s.

The change in momentum of the hand is 5.0 kg m/s.

The mass of the hand is 0.80 kg.

Calculate the final velocity of the hand.

Use the Physics Equations Sheet.

[4 marks]

Final velocity = _____ m/s

Do not write outside the box

As the hand exerts a force on the wooden board, the wooden board exerts a force on the hand.

0 5 . 2 Explain how Newton's third law applies to the hand hitting the wooden board.

[2 marks]

0 5 . 3 **Figure 11** shows the hand hitting the wooden board. When the hand hits the wooden board, the wooden board bends.

Figure 11

When the hand hits the wooden board, the hand moves through a distance of 1.2 cm while exerting a force on the wooden board.

The work done by the hand is 6.0 J.

Calculate the force the hand exerts on the wooden board.

Use the Physics Equations Sheet.

[4 marks]

Force = _____ N

10

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0 6 Hydrogen bromide decomposes to form hydrogen and bromine.

The equation for the reaction is:

$$2HBr \longrightarrow H_2 + Br_2$$

The energy needed to break the existing bonds is 103 kJ/mol greater than the energy released in forming new bonds.

0 6 . 1 **Table 3** shows some bond energy values.

Table 3

Bond	Bond energy in kJ/mol
H–Br	**Y**
H–H	436
Br–Br	193

Y is the bond energy of a H–Br bond.

Calculate **Y**.

[5 marks]

Y = _____ kJ/mol

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0 6 . 2 **Figure 12** shows part of the reaction profile when hydrogen bromide decomposes to form hydrogen and bromine.

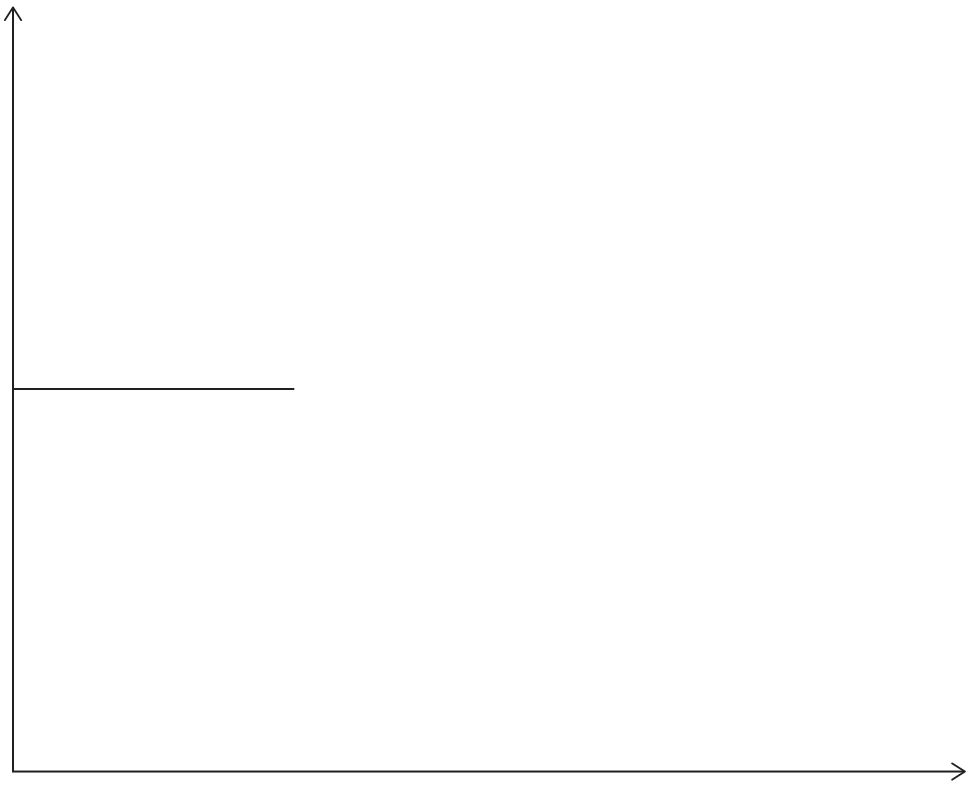
Complete **Figure 12**.

You should:

- label the axes
- draw the reaction profile
- label the reactant and the products
- label the activation energy.

[4 marks]

Figure 12



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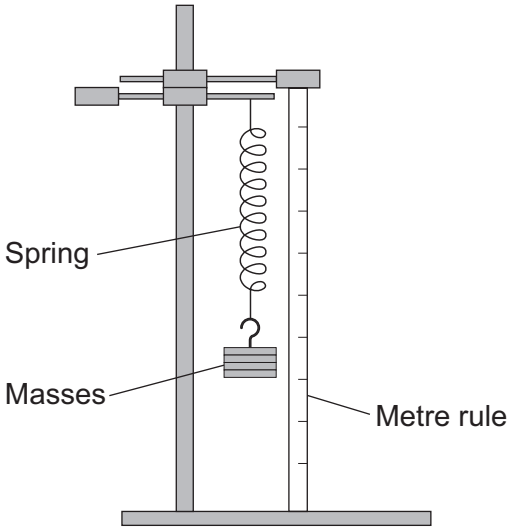
ANSWER IN THE SPACES PROVIDED

0 7 A student investigated how the extension of a spring varied with the force applied to the spring.

Figure 13 shows the equipment used.

Figure 13



This is the method used.

1. Measure the length of the unstretched spring.
2. Hang the spring from the clamp stand.
3. Hang a mass from the spring.
4. Calculate the weight of the mass.
5. Measure the new length of the spring.
6. Calculate the extension of the spring.
7. Repeat steps 3 to 6 for additional masses.

0 7 . 1 A spring can be elastically or inelastically deformed.

What does 'elastically deformed' mean?

[1 mark]

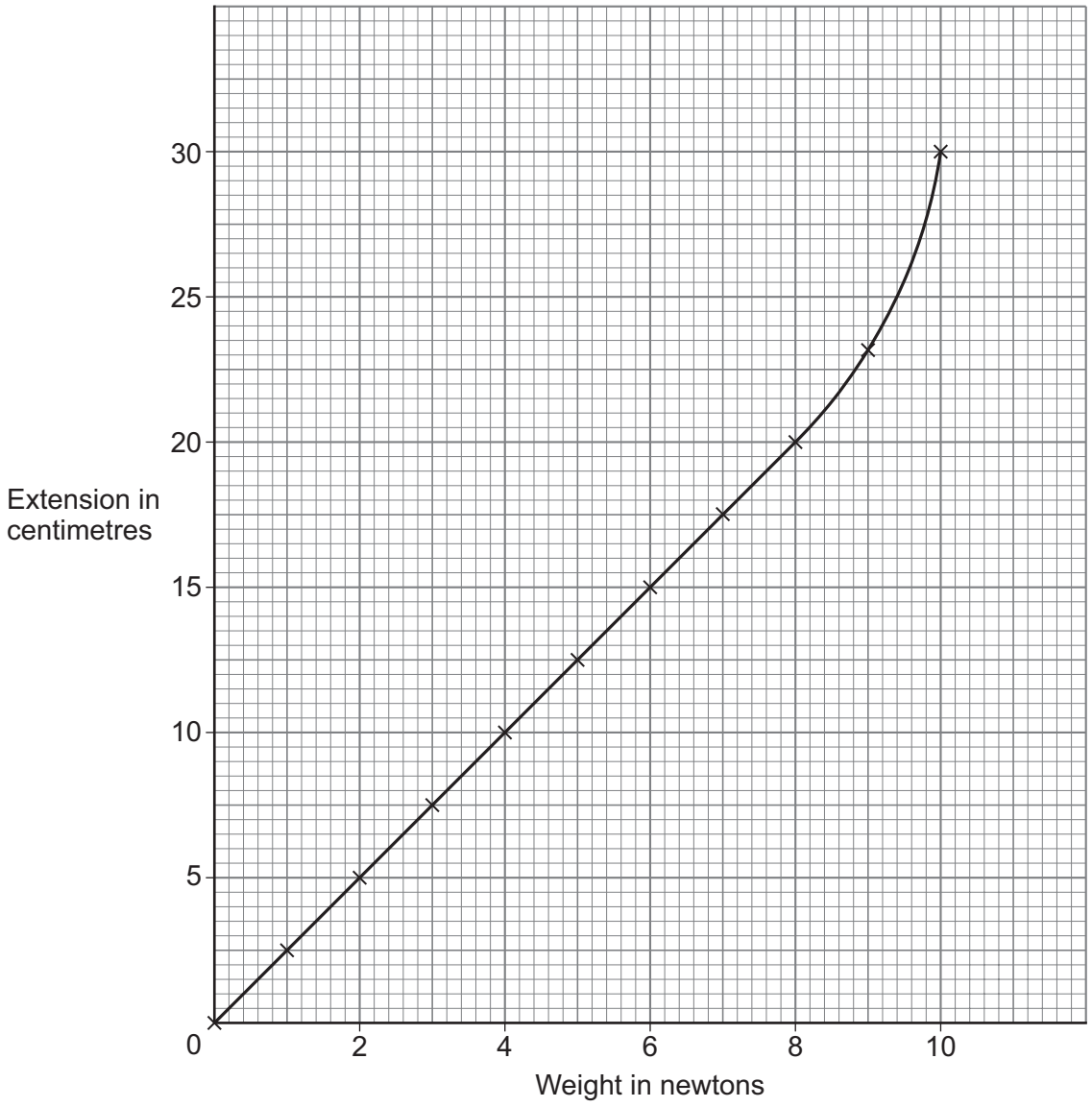
_____

_____

Question 7 continues on the next page

Figure 14 shows the results.

Figure 14



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0 7 . 2 The student concluded:

'The extension of the spring is directly proportional to the weight up to a point called the limit of proportionality.'

What was the extension of the spring when the spring reached its limit of proportionality?

[1 mark]

Extension = _____ cm

0 7 . 3 Determine the spring constant of the spring used by the student.

Use the Physics Equations Sheet.

[4 marks]

Spring constant = _____ N/m

Question 7 continues on the next page

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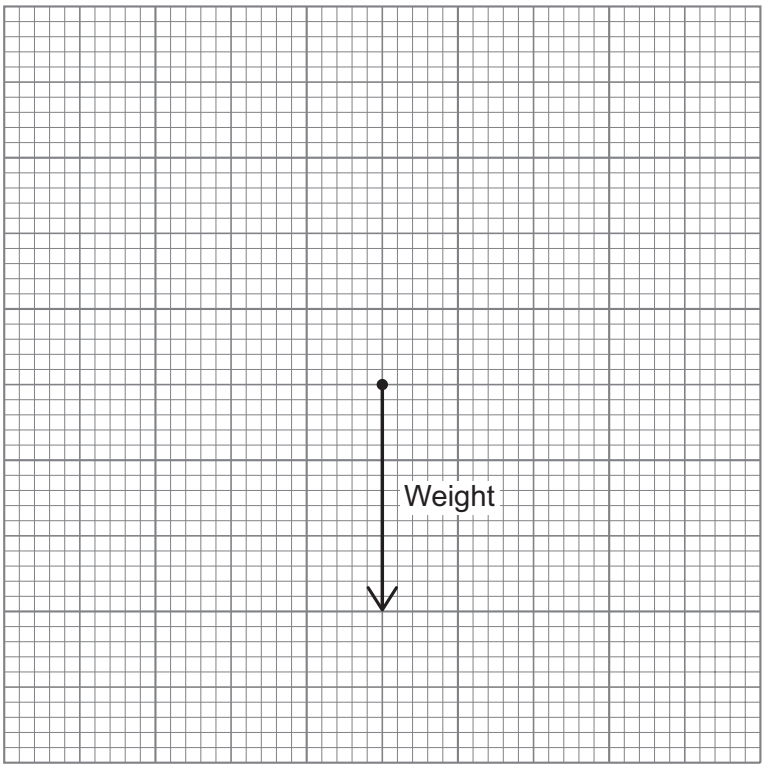
0 7 . 4 The mass on the spring is stationarity after the spring has extended.

The force that the mass exerts on the spring is represented by the vector diagram in **Figure 15**.

Figure 15



Draw an arrow on **Figure 15** to show the magnitude and direction of the tension in the spring.

[2 marks]

8

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ANSWER IN THE SPACES PROVIDED

0 8 A student investigated the reaction between calcium carbonate and hydrochloric acid.

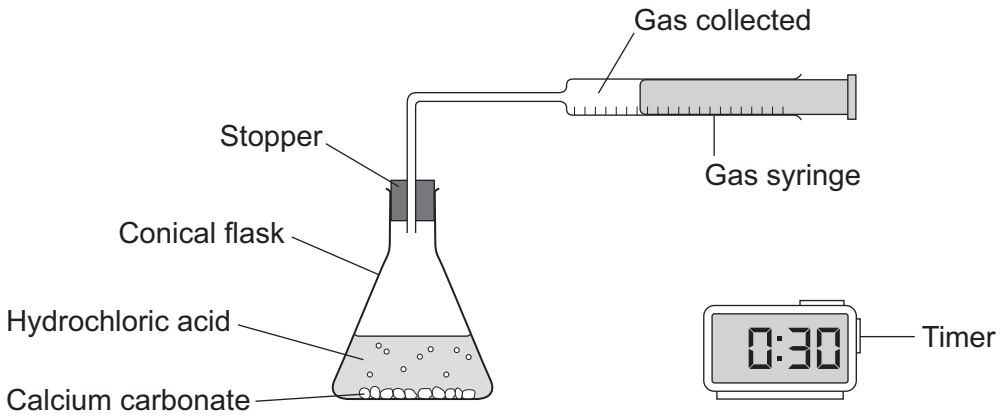
The equation for the reaction is:

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

The student investigated the effect of changing the concentration of hydrochloric acid on the rate of the reaction.

Figure 16 shows the apparatus.

Figure 16



This is the method used.

1. Add 50 cm^3 of hydrochloric acid to the conical flask.
2. Add 2.0 g of calcium carbonate to the conical flask.
3. Immediately insert the stopper into the conical flask and start the timer.
4. Record the volume of gas collected in the gas syringe every 30 seconds.
5. Stop recording when the volume of gas in the gas syringe does not change.
6. Repeat steps 1 to 5 using different concentrations of hydrochloric acid.

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0 8 . 1 Name the independent variable in this investigation.

[1 mark]

_____

_____

Question 8 continues on the next page

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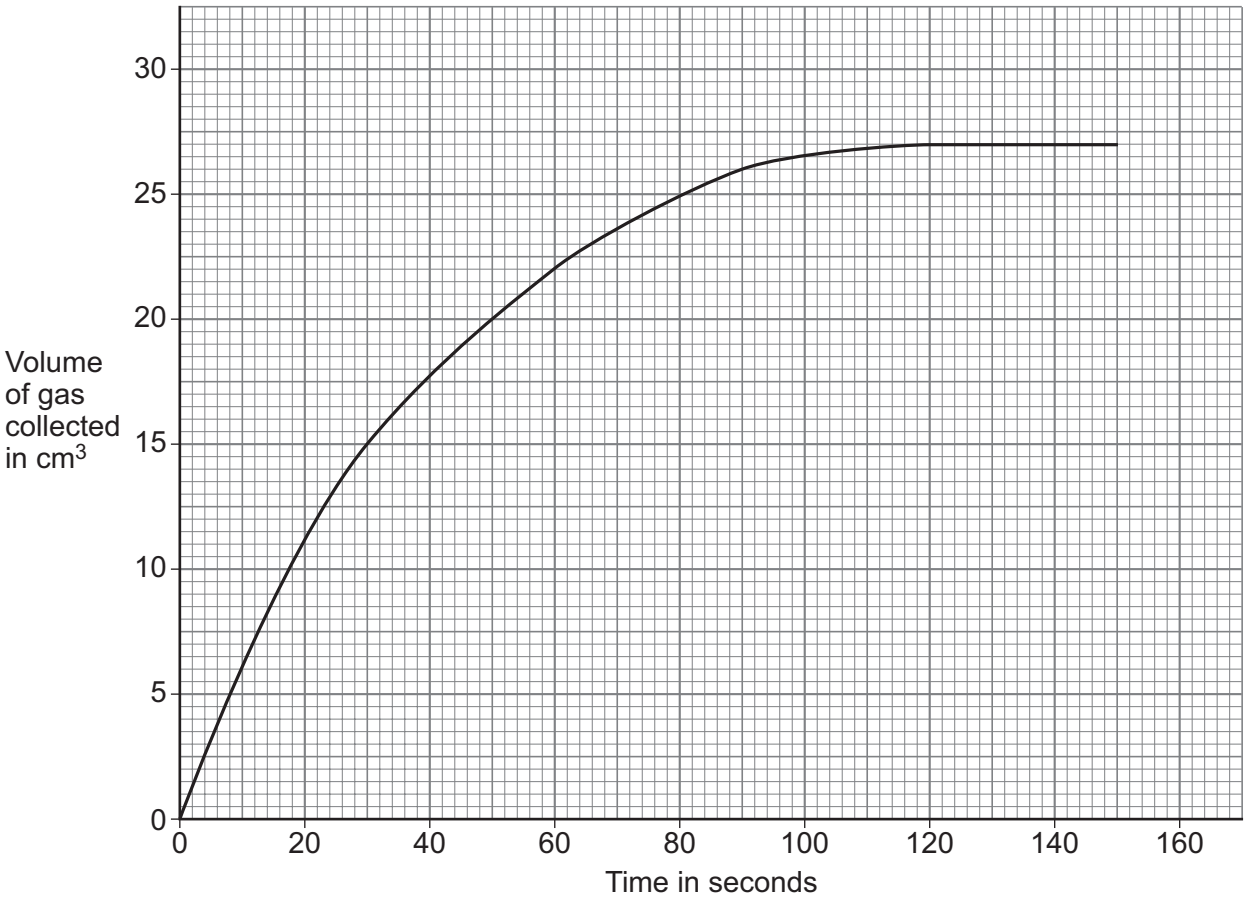
Figure 17 shows the results for one concentration of hydrochloric acid.

Figure 17



0 8 . 2 Determine the rate of reaction at 60 seconds.

Show your working on **Figure 17**.

Give your answer to 2 significant figures.

[5 marks]

Rate (2 significant figures) = _____ cm^3/s

Do not write outside the box

0 8 . 3 How does **Figure 17** show that the rate of reaction decreases with time?

[1 mark]

0 8 . 4 Explain why the rate of reaction between calcium carbonate and hydrochloric acid decreases with time.

[3 marks]

10

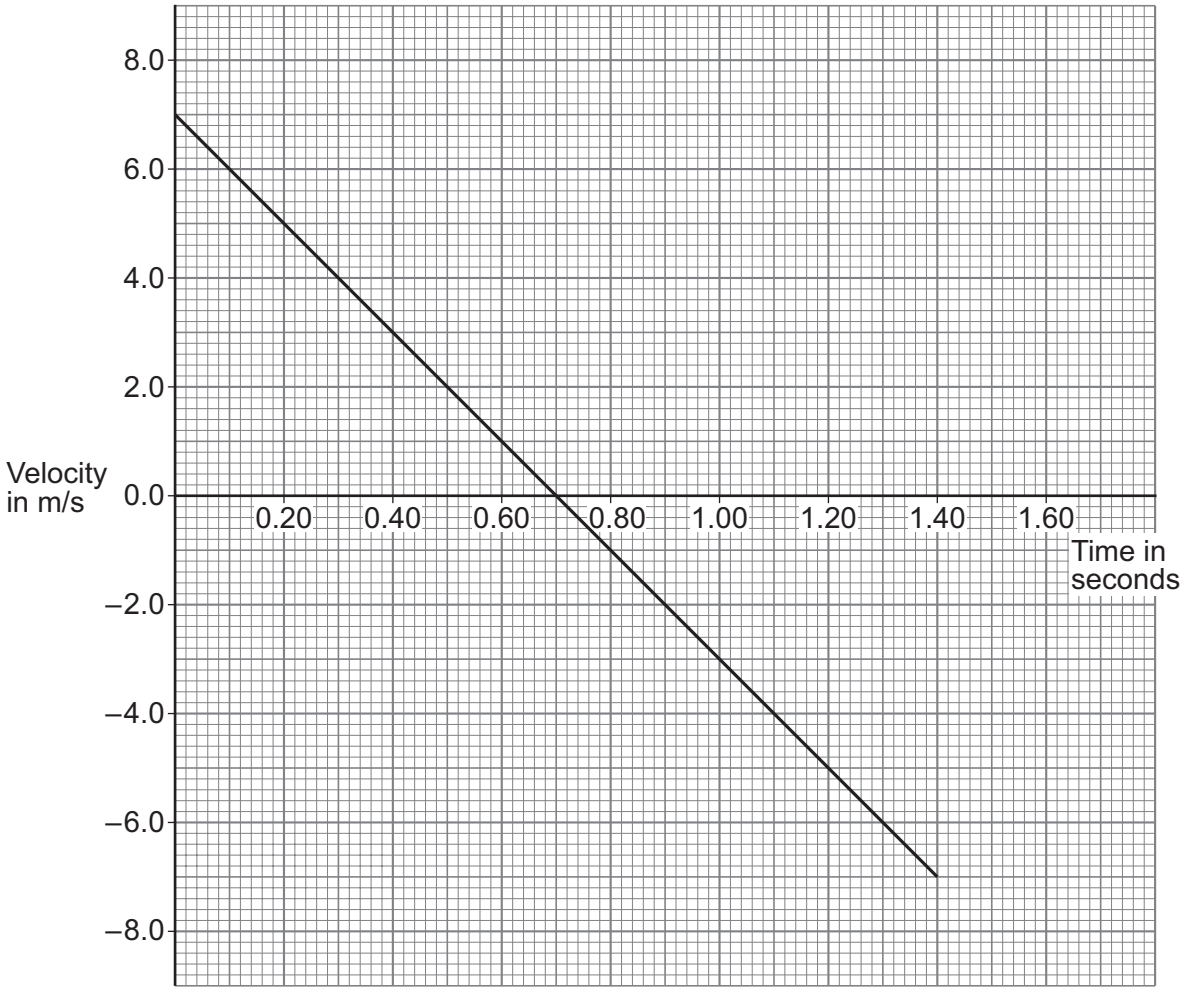
Turn over for the next question

Do not write outside the box

0 9 A student throws a ball vertically upwards in the air and catches the ball as it returns.

Figure 18 is a velocity-time graph of the ball's motion after leaving the student's hand until the ball is caught.

Figure 18



0 9 . 1 Determine the maximum height the ball reaches.

[2 marks]

Maximum height = _____ m

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0 9 . 2 The distance the ball travels when moving upwards is equal to the distance the ball travels when moving downwards.

Explain how **Figure 18** shows that the two distances are equal.

[2 marks]

Figure 18 does not include the effect that air resistance would have on the ball when it is in motion.

0 9 . 3 The graph in **Figure 18** is a straight line with a constant gradient.

Explain why the gradient is constant.

[2 marks]

0 9 . 4 Describe **two** ways the graph would change between 0.0 and 0.70 seconds if the effect of air resistance had been included.

[2 marks]

1

2

Question 9 continues on the next page

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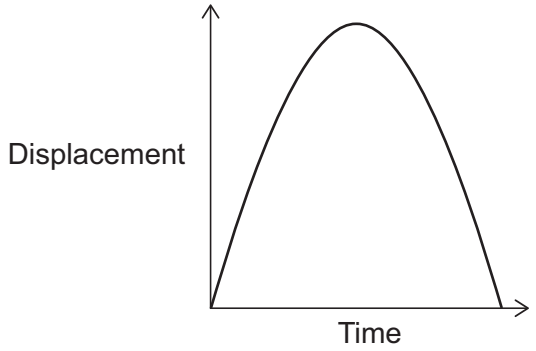
0 9 . 5 Which displacement-time graph represents the ball's motion after leaving the student's hand until the ball is caught?

[1 mark]

Tick (✓) **one** box.



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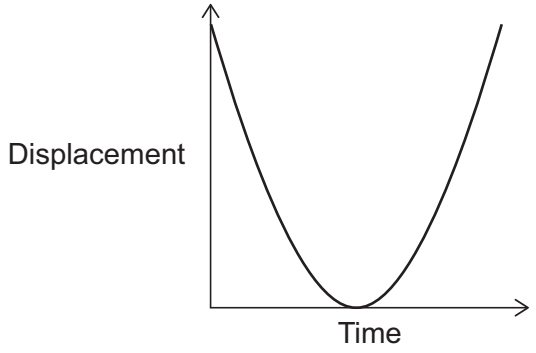

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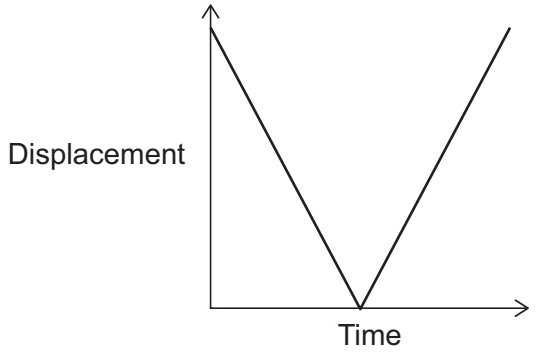

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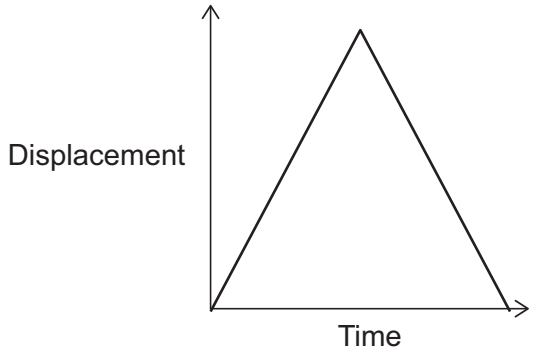

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9

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1 0 The stopping distance of a vehicle depends on the thinking distance and the braking distance.

1 0 . 1 What is meant by 'thinking distance'?

[1 mark]

1 0 . 2 What would increase the **thinking distance**?

[2 marks]

Tick (✓) **two** boxes.

- Ice on the road surface ☐
- Poor condition of the brakes ☐
- The driver being tired ☐
- Using a mobile phone while driving ☐
- Wet weather ☐

Question 10 continues on the next page

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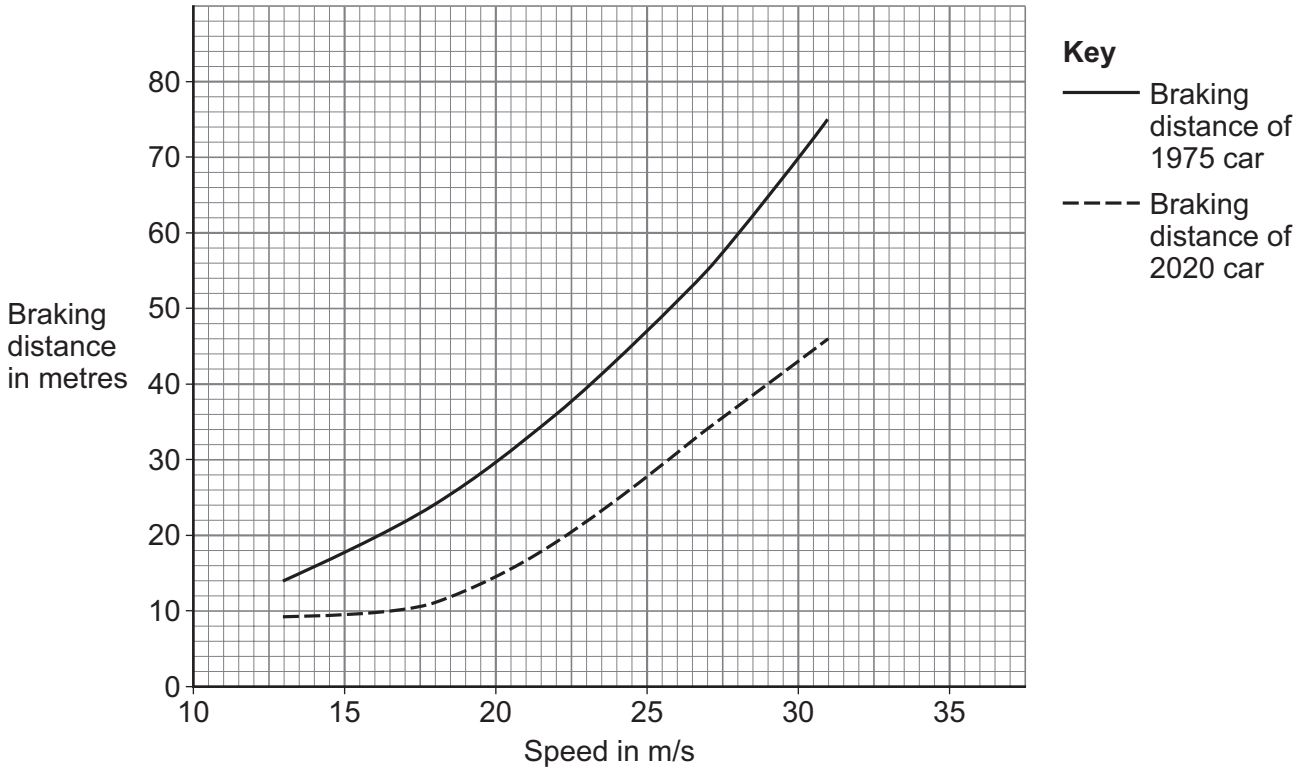
Figure 19 shows how the braking distance of a new car in 2020 compares with the braking distance of a new car in 1975.

Figure 19



1 0 . 3 The two cars had the same mass and were driven along a level road in sunny weather.

Explain the difference in **braking distance** between the two cars.

Use **Figure 19**.

[3 marks]

Do not write outside the box

1 0 . 4 The 2020 car was driven at a speed of 27 m/s. The brakes were applied until the car stopped.

The speed of the car decreased from 27 m/s to 0 m/s with a constant deceleration.

The mass of the car was 850 kg.

Determine the mean braking force on the car.

Use **Figure 19**.

Use the Physics Equations Sheet.

[6 marks]

Mean braking force = _____ N

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END OF QUESTIONS

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