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

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.

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

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

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

[1 mark]

The braking distance of a vehicle depends on the mass of the vehicle.

Use the Physics Equations Sheet to answer questions **01.2** and **01.3**.

0 1 . 2 Write down the equation which links gravitational field strength (g), mass (m) and weight (W).

[1 mark]

0 1 . 3 Calculate the mass of a vehicle with a weight of 14 700 N.

gravitational field strength = 9.8 N/kg

[3 marks]

Mass = _____ kg

Question 1 continues on the next page

Do not write outside the box

The thinking distance travelled by a vehicle depends on the reaction time of the driver.

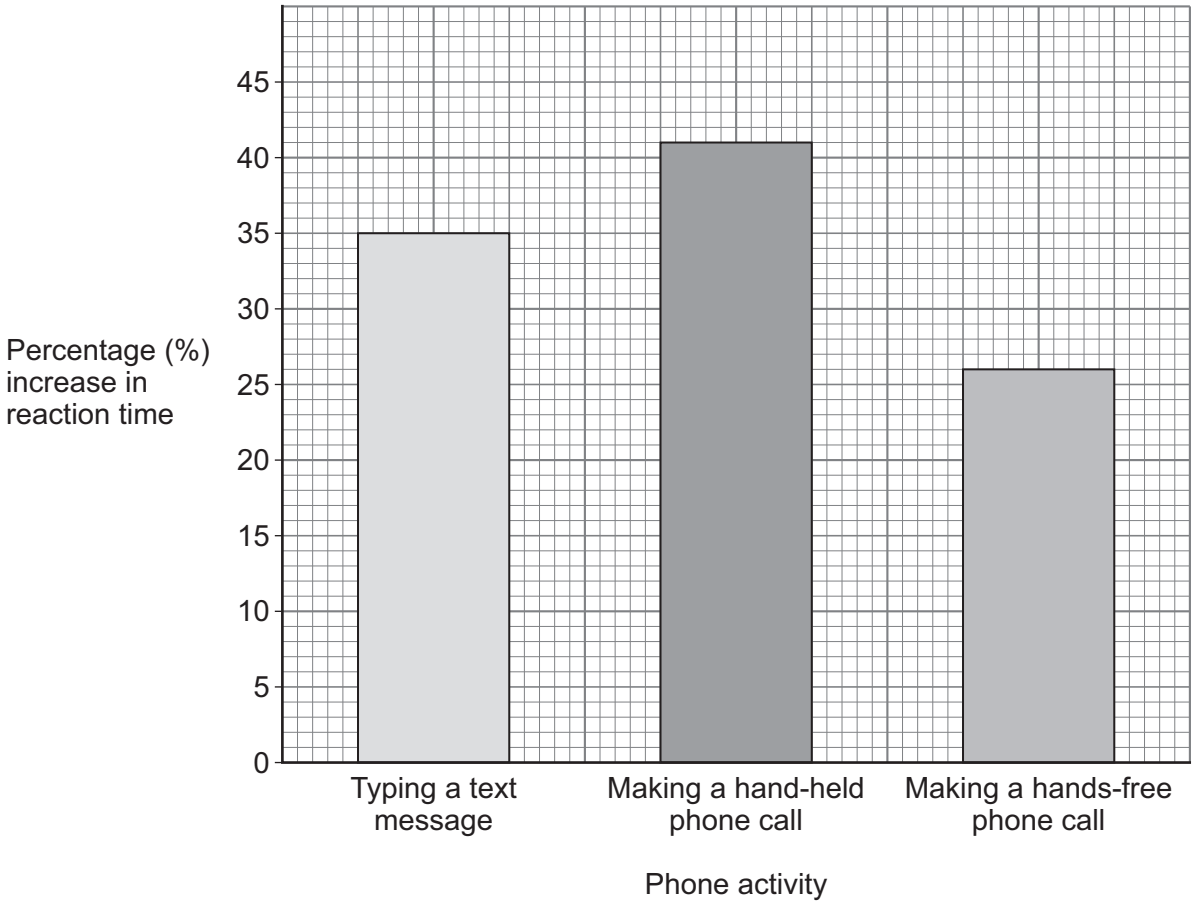
Using a mobile phone increases a driver's reaction time.

A mobile phone can be used in these ways:

- typing a text message
- making a phone call while holding the phone
- making a hands-free phone call using the car's audio system.

Figure 1 shows how different activities using a mobile phone affect a driver's reaction time.

Figure 1



Do not write outside the box

0 1 . 4 The reaction time of a typical driver is 0.50 s.

Calculate the reaction time of a typical driver typing a text message while driving.

[3 marks]

Reaction time = _____ s

0 1 . 5 The legal alcohol limit is the maximum amount of alcohol a person can have in the bloodstream and still legally drive.

The reaction time of a typical driver at the legal alcohol limit is increased by 12%.

A student suggests that it should be illegal to use a mobile phone in any way while driving.

Explain how the information in **Figure 1** supports the student's suggestion.

[4 marks]

12

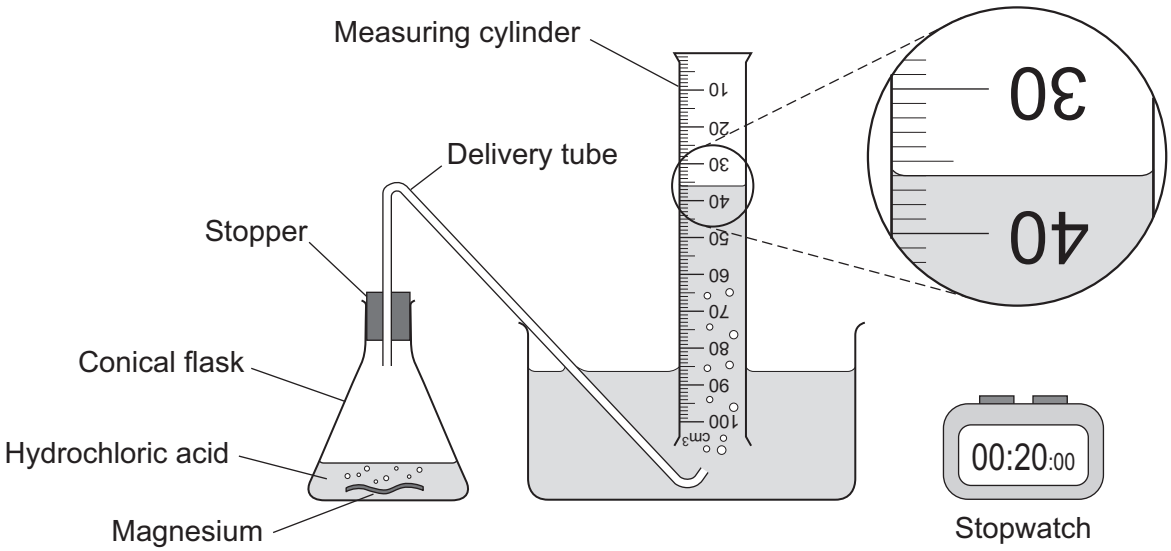
Do not write outside the box

0 2 Magnesium reacts with hydrochloric acid.

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

Figure 2 shows the apparatus.

Figure 2



This is the method used.

1. Add 50 cm^3 of hydrochloric acid to the conical flask.
2. Add a 3 cm strip of magnesium to the hydrochloric acid in the conical flask.
3. Fit the stopper and delivery tube to the top of the conical flask and start timing.
4. Record the volume of hydrogen gas collected in the measuring cylinder every 20 seconds for a total of 100 seconds.
5. Repeat steps 1 to 4 with a different concentration of hydrochloric acid.

Do not write outside the box

0 2 . 1 What volume of hydrogen gas has been collected in the measuring cylinder in **Figure 2**?

[1 mark]

Volume = _____ cm^3

0 2 . 2 The stopper and delivery tube were fitted to the conical flask in step **3**.

Explain why the time taken to fit the stopper and delivery tube may cause an error in this investigation.

[2 marks]

_____

_____

_____

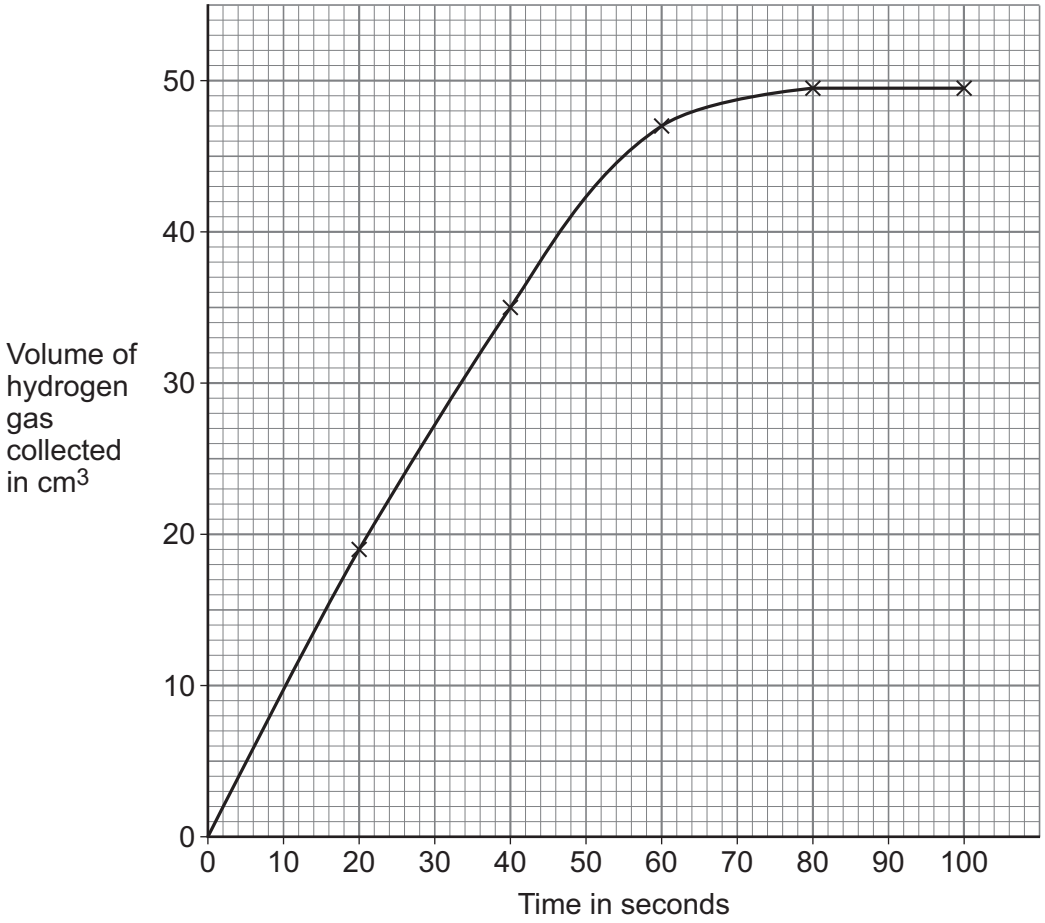
_____

Question 2 continues on the next page

Do not write outside the box

Figure 3 shows the results for one concentration of hydrochloric acid.

Figure 3



0 2 . 3 Determine the time taken for the reaction to be complete.

Use **Figure 3**.

[1 mark]

Time taken = _____ s

Do not write outside the box

0 2 . 4 The student repeated the method using a higher concentration of hydrochloric acid.

How would the line of best fit for a higher concentration of hydrochloric acid compare with the line of best fit on **Figure 3**?

[1 mark]

Tick (✓) **one** box.

Initially the line of best fit would have a lower gradient. ☐

Initially the line of best fit would have the same gradient. ☐

Initially the line of best fit would have a higher gradient. ☐

0 2 . 5 Describe the test for hydrogen gas.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

7

Turn over for the next question

Do not write outside the box

0 3 A student investigated magnetic fields.

Figure 4 shows a cube-shaped magnet and a magnetic compass.

Figure 4



0 3 . 1 Describe how the student could identify the poles of the magnet using the magnetic compass.

[2 marks]

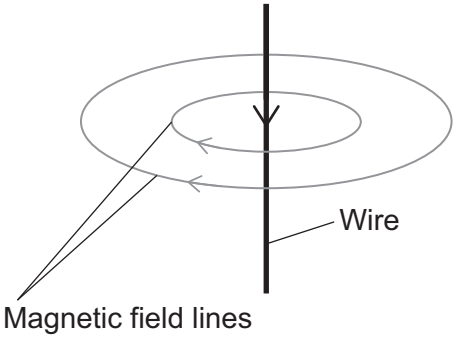
Do not write outside the box

Figure 5 shows a wire with a current in it.

The arrow shows the direction of the current in the wire.

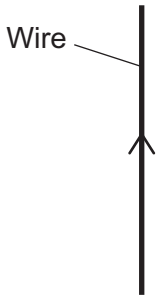
There is a magnetic field around the wire.

Figure 5



0 3 . 2 **Figure 6** shows the wire when the current is in the opposite direction to **Figure 5**.

Figure 6



Complete **Figure 6** to show the magnetic field around the wire.

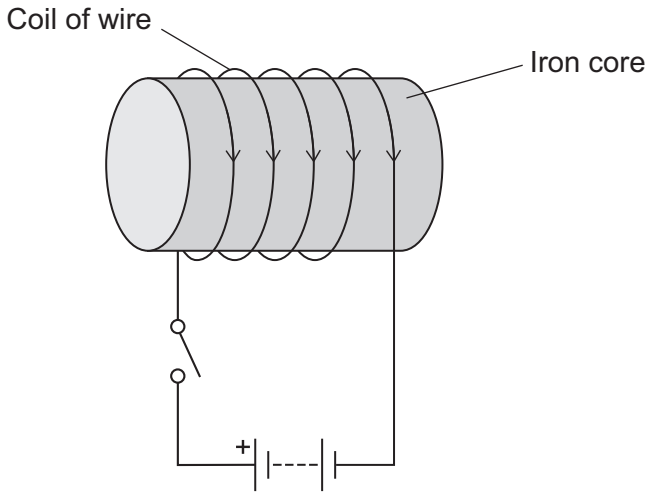
[1 mark]

Question 3 continues on the next page

Do not write outside the box

0 3 . 3 **Figure 7** shows an electromagnet made from a coil of wire wrapped around an iron core.

Figure 7



When the switch is closed, there is a magnetic field around the electromagnet.

Label on **Figure 7**:

- the north pole **N**
- the south pole **S**.

[1 mark]

Do not write outside the box

The student opened the switch and placed a paper clip near the electromagnet.

When the switch was closed, the paper clip accelerated towards the electromagnet.

Use the Physics Equations Sheet to answer questions **03.4** and **03.5**.

0 3 . 4 Write down the equation which links acceleration (*a*), mass (*m*) and resultant force (*F*).

[1 mark]

_____

0 3 . 5 The initial resultant force on the paper clip was 4.8×10^{-3} N.

Calculate the initial acceleration of the paper clip.

mass of paper clip = 4.0×10^{-4} kg

[3 marks]

_____

_____

_____

_____

_____

Initial acceleration = _____ m/s^2

0 3 . 6 Explain why the acceleration of the paper clip changes as the paper clip moves towards the magnet.

[2 marks]

_____

_____

_____

_____

10

Turn over ▶

Do not write outside the box

0 4 This question is about life cycle assessments (LCAs).

Shopping bags can be made from paper or plastic.

Table 1 gives some information from LCAs about the environmental impact of paper bags and plastic bags.

Each type of bag can carry the same volume of shopping.

Table 1

	Paper bag	**Plastic bag**
Raw material	wood	crude oil
Mass of 1 bag in grams	56	35
Water used to produce 1 bag in litres	0.14	0.04
Energy used to produce 1 bag in kJ	90	22
Mean number of times the bag is used	1	3
Biodegradable	Yes	No
Recyclable	Yes	Yes

Do not write outside the box

Evaluate the use of paper compared with the use of plastic for shopping bags.

Use **Table 1** and your knowledge and understanding of LCAs.

[6 marks]

6

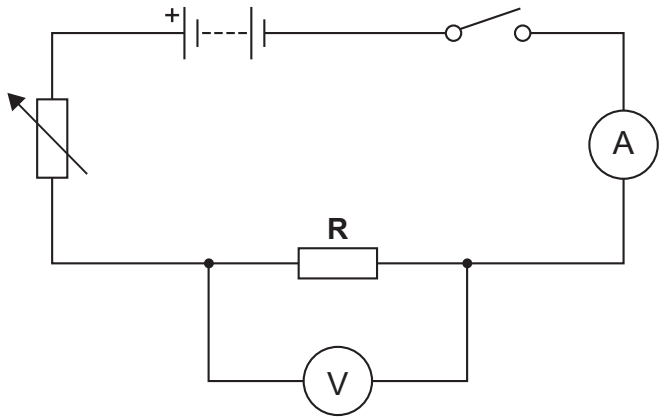
Turn over for the next question

Do not write outside the box

0 5 A student carried out an investigation using an electrical circuit.

Figure 8 shows the circuit used.

Figure 8



0 5 . 1 The student increased the resistance of the variable resistor.

Describe what happened to the potential difference across resistor **R** and the current in resistor **R**.

[2 marks]

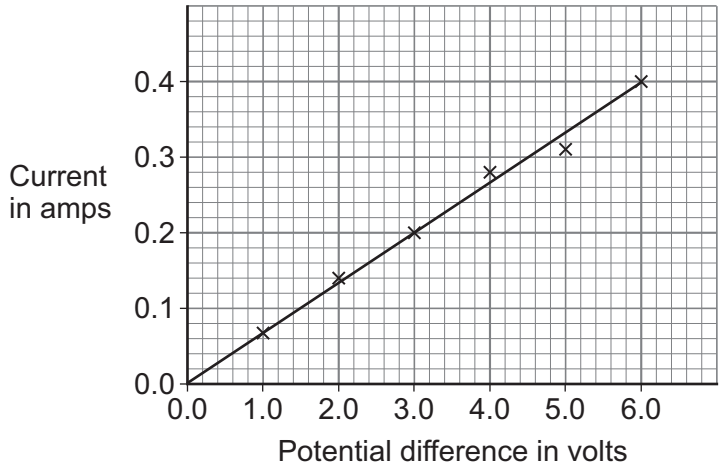
Do not write outside the box

The student investigated how the current in resistor **R** varied with the potential difference across resistor **R**.

To keep the temperature of resistor **R** constant, the student opened the switch after taking each reading.

Figure 9 shows the results.

Figure 9



0 5 . 2 Explain what happens to the resistance of resistor **R** as the potential difference across resistor **R** increases.

Use information from **Figure 9**.

[2 marks]

_____

_____

_____

_____

Question 5 continues on the next page

Do not write outside the box

0 5 . 3 After the reading was taken at 4.0 V, the student did **not** open the switch before taking the reading at 5.0 V.

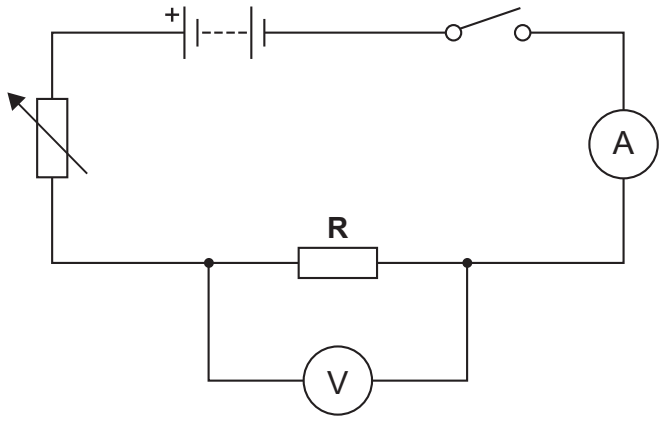
Explain why the current was lower than expected when the 5.0 V reading was taken.

[2 marks]

Do not write outside the box

0 5 . 4 **Figure 8** is repeated below.

Figure 8



The student had more resistors with the same resistance as resistor **R**.

Describe a method to investigate how the number of resistors in parallel affects the total resistance of the resistors in parallel.

[4 marks]

10

Do not write outside the box

0 6 This question is about ammonia.

Nitrogen gas reacts with hydrogen gas to produce ammonia gas in a reversible reaction.

The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

0 6 . 1 What is the effect of increasing the pressure on the equilibrium position in this reaction?

[1 mark]

Tick (✓) **one** box.

The equilibrium position shifts towards the side with the smaller number of molecules. ☐

The equilibrium position is unchanged. ☐

The equilibrium position shifts towards the side with the larger number of molecules. ☐

0 6 . 2 The reaction to produce ammonia gas is exothermic.

What is the effect of increasing the temperature on the relative amount of ammonia at equilibrium?

[1 mark]

Tick (✓) **one** box.

The relative amount of ammonia decreases. ☐

The relative amount of ammonia stays the same. ☐

The relative amount of ammonia increases. ☐

Do not write outside the box

0 6 . 3 How must the apparatus for the reaction be designed so that dynamic equilibrium can be reached?

[1 mark]

_____

_____

0 6 . 4 Explain what happens to the relative amounts of nitrogen, hydrogen and ammonia after dynamic equilibrium has been reached.

[2 marks]

_____

_____

_____

_____

Question 6 continues on the next page

Do not write outside the box

Ammonia reacts with hydrogen chloride to produce ammonium chloride (NH_4Cl).

The equation for the reaction is:

$$NH_3 + HCl \rightarrow NH_4Cl$$

6.8 g of ammonia reacts with excess hydrogen chloride.

0 6 . 5 Explain why ammonia is described as the limiting reactant in this reaction.

[2 marks]

0 6 . 6 Calculate the maximum mass of ammonium chloride that could be produced from 6.8 g of ammonia.

Relative atomic masses (A_r): N = 14 H = 1 Cl = 35.5

[4 marks]

Maximum mass = _____ g

11

Do not write outside the box

Turn over for the next question

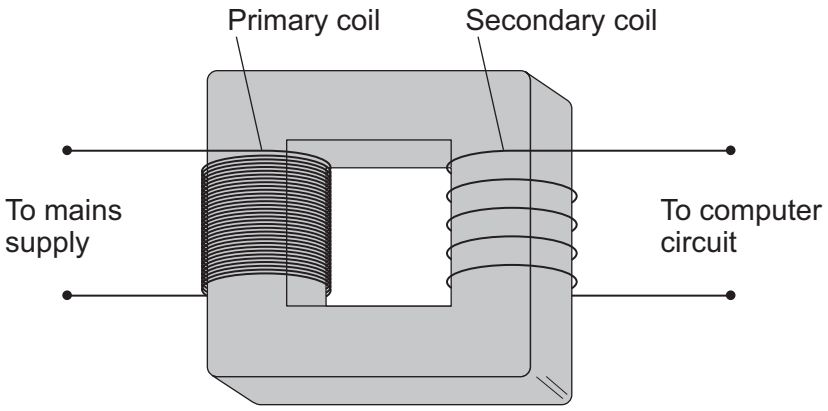
DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 7 **Figure 10** shows a step-down transformer that is part of a circuit inside a computer.

The transformer connects the mains supply to the computer circuit.

Figure 10



0 7 . 1 The potential difference across the primary coil is 230 V.

The potential difference across the secondary coil is 48.0 V.

The current in the primary coil is 2.40 A.

Calculate the current in the secondary coil.

Use the Physics Equations sheet.

[3 marks]

Current in the secondary coil = _____ A

Do not write outside the box

0 7 . 2 The current in the primary coil is 2.40 A.

Calculate the time taken for a charge of 288 C to flow past a point in the primary coil.

Use the Physics Equations Sheet.

Give your answer in minutes.

[3 marks]

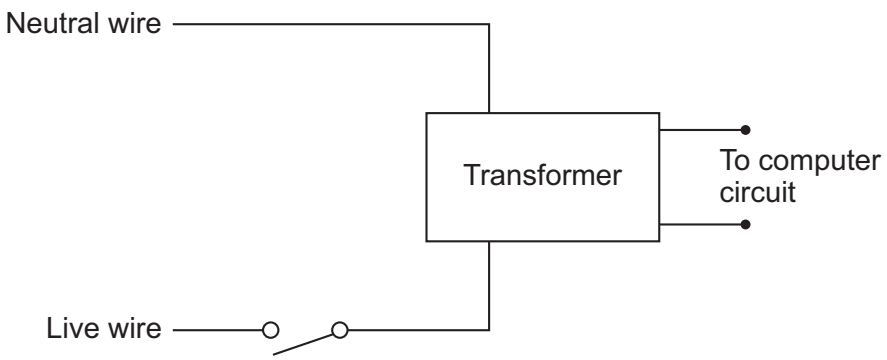
Time = _____ minutes

Question 7 continues on the next page

Do not write outside the box

0 7 . 3 **Figure 11** shows the mains electricity circuit for the transformer.

Figure 11



An electrician replaced a faulty switch connecting the transformer to the mains supply.

The circuit was disconnected from the mains supply to prevent the electrician from receiving an electric shock.

Explain why the electrician could have received a shock if the circuit was connected.

[3 marks]

Do not write outside the box

0 7 . 4 **Table 2** shows information about the effects of different electrical supplies on the human body.

Table 2

Effect on the human body	Minimum current needed to cause the effect in milliamps		
	50 Hz ac supply	10 000 Hz ac supply	dc supply
Mild pain	8	46	52
Moderate pain	14	63	64
Severe pain	19	79	75

ac is alternating current.

dc is direct current.

The mains electricity supply in the UK is ac with a frequency of 50 Hz.

Describe why it would be better if the UK mains supply was **not** 50 Hz ac.

[3 marks]

12

Do not write outside the box

0 8 This question is about acids and alkalis.

0 8 . 1 Magnesium reacts with acids to produce a salt and hydrogen.

The ionic equation for the reaction is:

$$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$$

In a redox reaction, both oxidation **and** reduction occur.

Explain why this reaction is described as a redox reaction.

[2 marks]

0 8 . 2 What happens to the pH of an acid when the hydrogen ion concentration decreases by a factor of ten?

[1 mark]

Tick (✓) **one** box.

The pH decreases by 1. ☐

The pH decreases by 10. ☐

The pH increases by 1. ☐

The pH increases by 10. ☐

Do not write outside the box

0 8 . 3 Write the ionic equation that represents the neutralisation reaction between an acid and an alkali in aqueous solution.

You should include state symbols.

[2 marks]

_____ + _____ → _____

A teacher demonstrates the reaction of potassium with water.

0 8 . 4 Give **two** observations seen when potassium reacts with water.

[2 marks]

1 _____

_____

2 _____

_____

0 8 . 5 Potassium reacts with water to form a solution with a pH of 13.

Explain why the solution has a pH of 13.

You should refer to ions in your answer.

[3 marks]

_____

_____

_____

_____

_____

_____

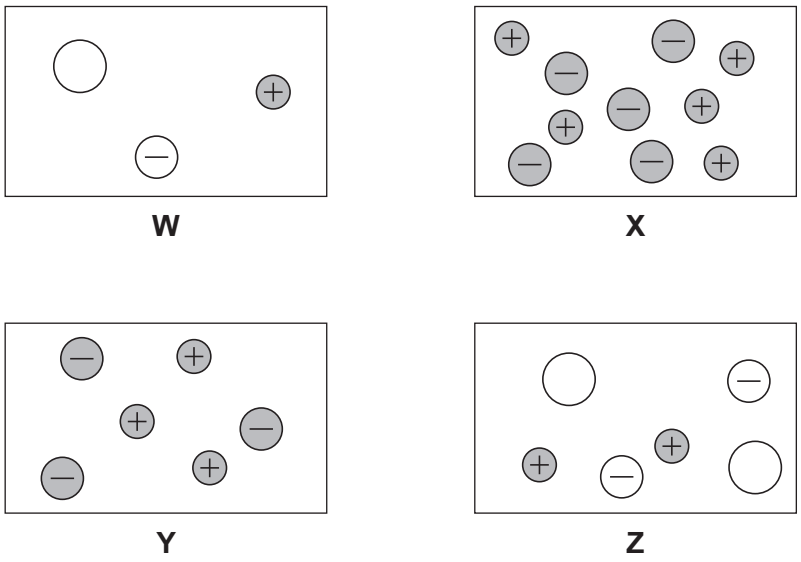
Question 8 continues on the next page

Do not write outside the box

Figure 12 shows four models representing the same volume of:

- a strong acid at two different concentrations
- a weak acid at two different concentrations.

Figure 12



0 8 . 6 Which model represents the weak acid with the higher concentration?

[3 marks]

Tick (✓) **one** box.

W ☐ **X** ☐ **Y** ☐ **Z** ☐

Justify your answer.

Do not write outside the box

0 8 . 7 Give **two** limitations of using the models in **Figure 12** to represent acids.

[2 marks]

1 _____

_____

2 _____

_____

15

Turn over for the next question

Do not write outside the box

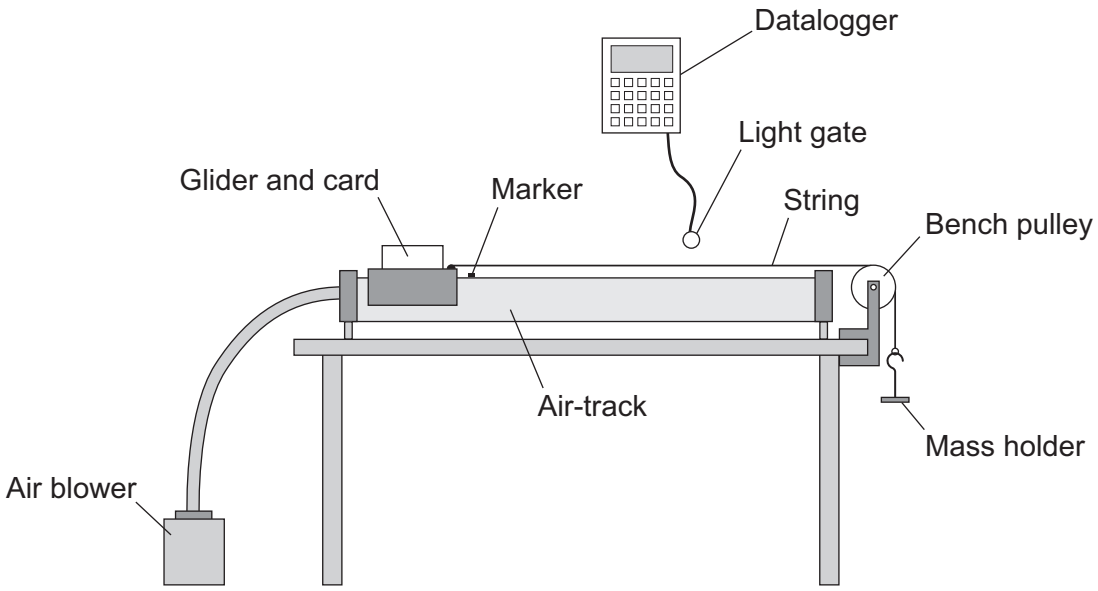
0 9 A student investigated how the acceleration of a glider varied with the mass of the glider.

The force causing the acceleration was constant.

Figure 13 shows the equipment used.

The air blower allows the glider to move along the air-track with very little friction.

Figure 13



This is the method used.

1. Line up the front of the glider with the marker.
2. Release the glider.
3. Record the velocity as the glider passes through the light gate.
4. Calculate the acceleration of the glider.
5. Repeat steps 1 to 4 using gliders of different mass.

Do not write outside the box

0 9 . 1 The mass on the mass holder was 25 g.

The change in gravitational potential energy of the mass was 0.147 J.

gravitational field strength = 9.8 N/kg

Calculate the change in height of the mass.

Use the Physics Equations Sheet.

[4 marks]

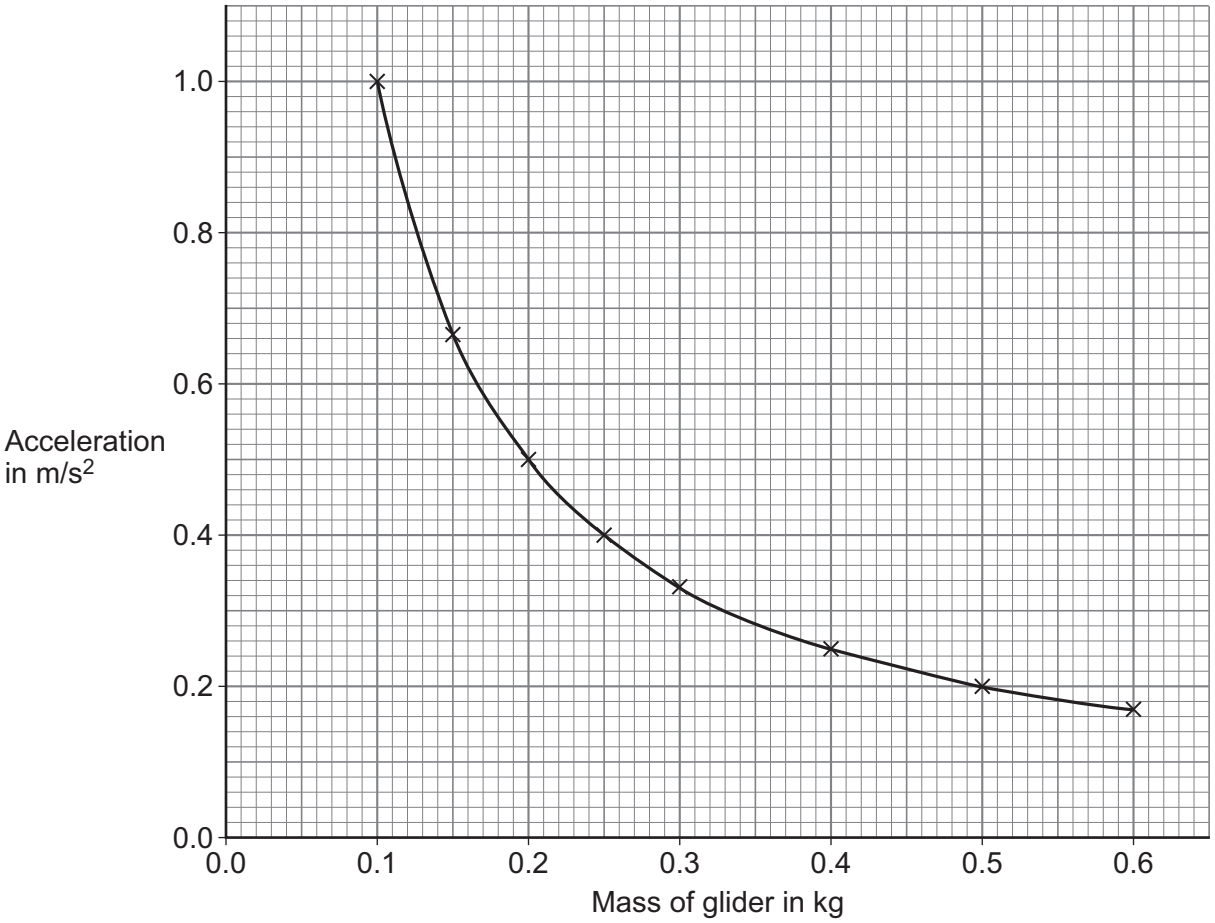
Change in height = _____ m

Question 9 continues on the next page

Do not write outside the box

0 9 . 2 **Figure 14** shows the results.

Figure 14



The student concluded:

'The acceleration of the glider is inversely proportional to the mass of the glider.'

Explain why the student was correct.

Use data from **Figure 14** in your answer.

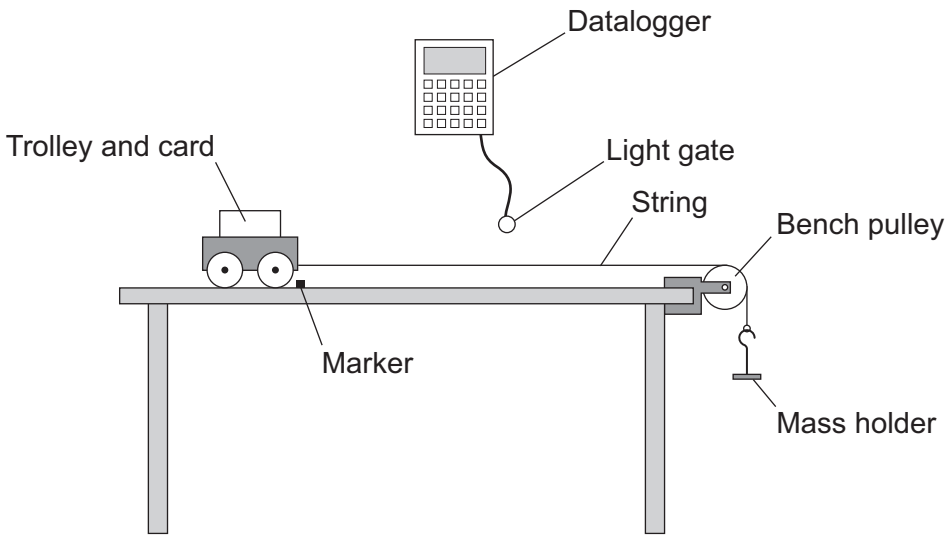
[3 marks]

Do not write outside the box

0 9 . 3 A different student did the investigation using a trolley instead of an air blower and glider.

Figure 15 shows the equipment.

Figure 15



Give **one** way that the student could make the trolley roll more easily along the bench.
[1 mark]

_____

_____

8

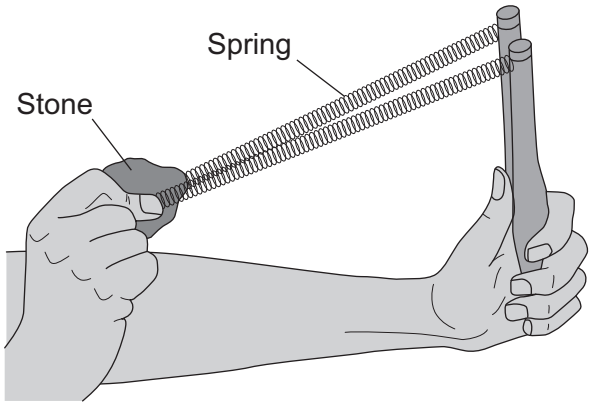
Turn over for the next question

Do not write outside the box

1 0 **Figure 16** shows a student using a catapult to launch a small stone.

The catapult contains a spring.

Figure 16



1 0 . 1 What is the relationship between the extension of a spring and the force applied to the spring?

[1 mark]

_____

_____

1 0 . 2 The extension of the spring is 20 cm.

The elastic potential energy stored by the spring is 1.16 J.

Calculate the spring constant of the spring.

Use the Physics Equations Sheet.

[3 marks]

_____

_____

_____

_____

_____

Spring constant = _____ N/m

Do not write outside the box

1 0 . 3 The student used the catapult to launch stone **A** and then stone **B**.

The spring had the same extension for each stone.

Stone **B** has a mass 4 times greater than stone **A**.

Explain the difference in the speed of stone **A** and the speed of stone **B** as they are launched from the catapult.

Your answer should include a calculation.

Use the Physics Equations Sheet.

[3 marks]

Question 10 continues on the next page

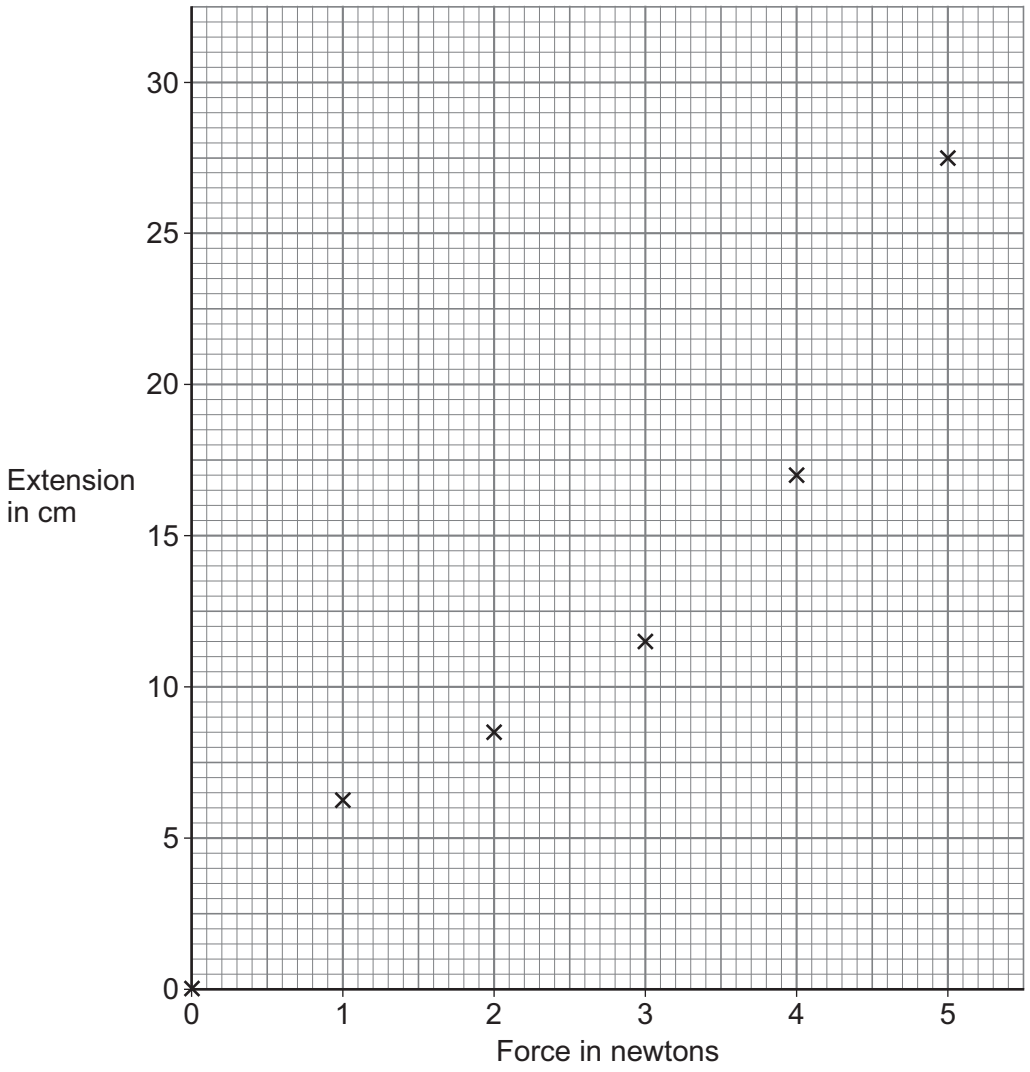
Do not write outside the box

1 0 . 4 Some catapults use a rubber band instead of a spring.

A student investigated how the extension of a rubber band varied with the force on the rubber band.

Figure 17 shows the results.

Figure 17



Do not write outside the box

Explain why additional readings would allow the student to make a conclusion more easily.

Do **not** refer to repeat readings or calculating a mean.

[2 marks]

_____

_____

_____

_____

9

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright information

For confidentiality purposes, all acknowledgements of third-party copyright material are published in a separate booklet. This booklet is published after each live examination series and is available for free download from www.aqa.org.uk.

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.

Copyright © 2022 AQA and its licensors. All rights reserved.