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

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.

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.

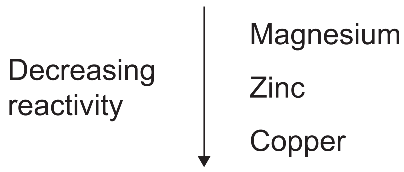
For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
TOTAL	

0 1 This question is about reactions of metals.

A student investigated the reactivity of three metals.

Figure 1 shows the order of reactivity of the three metals.

Figure 1



The student added each metal to three different metal sulfate solutions.

Table 1 shows some of the results.

Table 1

	Metal sulfate solution		
Metal	**Magnesium sulfate**	**Zinc sulfate**	**Copper sulfate**
Magnesium	✗		
Zinc	✗	✗	✓
Copper			✗

Key
✓ reaction occurs
✗ no reaction

A more reactive metal displaces a less reactive metal from a compound.

0 1 . 1 Complete **Table 1**.

Use:

- ✓ where a reaction occurs
- ✗ where there is no reaction.

Use **Figure 1**.

[2 marks]

0 1 . 2 Zinc reacts with copper sulfate to produce zinc sulfate and copper.

Complete the word equation for the reaction.

[1 mark]

zinc + ____________________ → ____________________ + ____________________

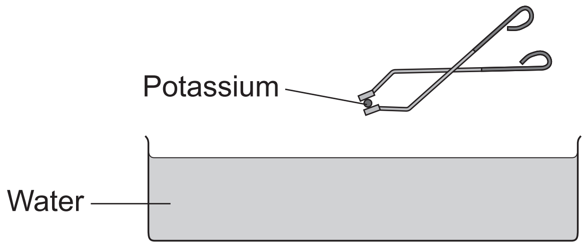
Question 1 continues on the next page

Potassium is in Group 1 of the periodic table.

A teacher demonstrated the reaction of potassium with water.

Figure 2 shows the apparatus.

Figure 2



0 1 . 3 What type of solution is formed when potassium reacts with water?

[1 mark]

Tick (✓) **one** box.

Acidic ☐

Alkaline ☐

Neutral ☐

0 1 . 4 Which gas is produced when potassium reacts with water?

[1 mark]

Tick (✓) **one** box.

Carbon dioxide ☐

Hydrogen ☐

Oxygen ☐

0 1 . 5 Give **one** observation seen when potassium is added to water.

[1 mark]

____

____

0 1 . 6 Sodium is above potassium in Group 1 of the periodic table.

How does the reactivity of sodium compare with the reactivity of potassium?

[1 mark]

Tick (✓) **one** box.

Sodium is less reactive than potassium. ☐

Sodium has the same reactivity as potassium. ☐

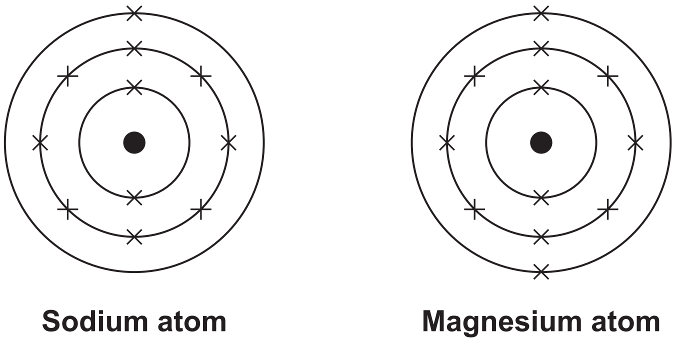
Sodium is more reactive than potassium. ☐

Question 1 continues on the next page

Do not write outside the box

0 1 . 7 **Figure 3** shows the electronic structure of two different atoms.

Figure 3



A sodium atom forms a Na^{+} ion.

Which ion does a magnesium atom form?

[1 mark]

Tick (✓) **one** box.

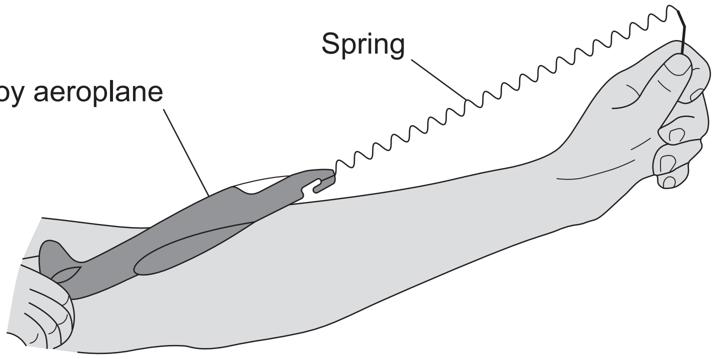
Mg^{+} ☐ Mg^{-} ☐ Mg^{2+} ☐ Mg^{2-} ☐

8

0 2 **Figure 4** shows a student launching a toy aeroplane.

The student pulls on the aeroplane to stretch the spring and then lets go of the aeroplane.

Figure 4



0 2 . 1 Give **one** factor that would affect how high the aeroplane goes.

[1 mark]

____

0 2 . 2 The extension of the spring is 0.20 m.

Calculate the elastic potential energy stored by the spring.

spring constant = 27 N/m

Use the equation:

$$\text{elastic potential energy} = 0.5 \times \text{spring constant} \times (\text{extension})^2$$

[2 marks]

____

____

____

Elastic potential energy = ______________________ J

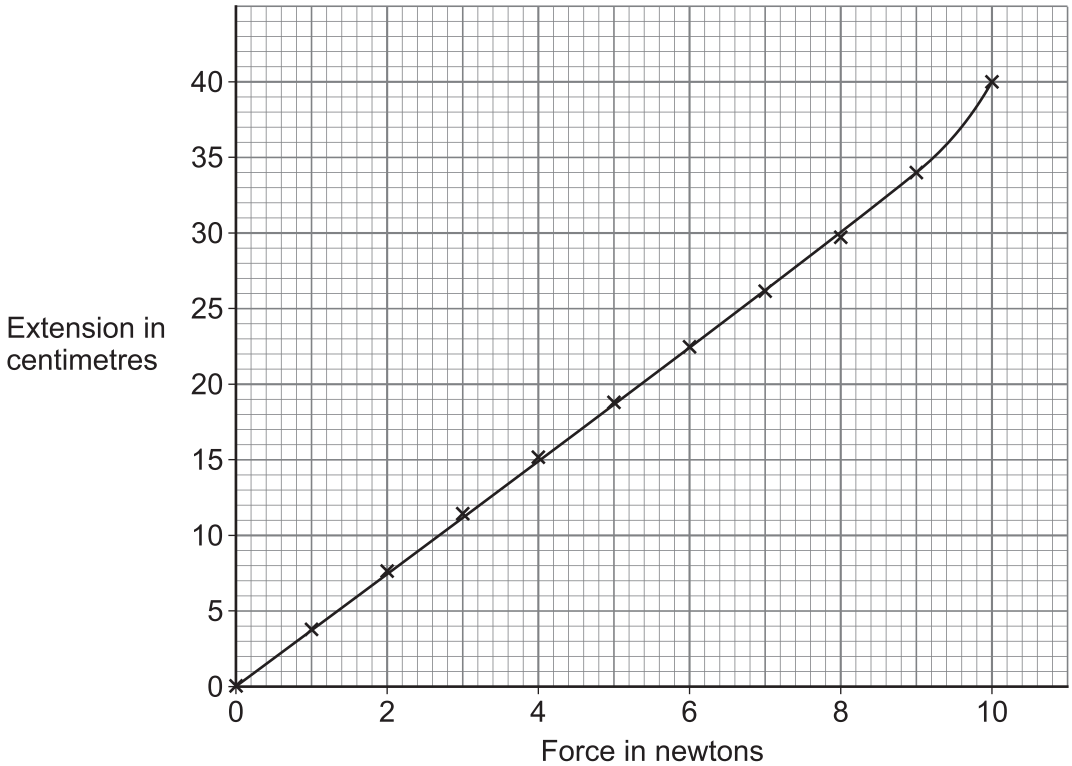
Question 2 continues on the next page

Turn over ▶

A student investigated how the extension of the spring varied as the force on the spring was increased.

Figure 5 shows the results.

Figure 5



0 2 . 3 What is a correct conclusion about the relationship between force and extension from 0 to 9 N?

[1 mark]

Tick (✓) **one** box.

Force and extension are inversely proportional. ☐

Force and extension have a linear relationship. ☐

Force and extension show a negative correlation. ☐

Do not write outside the box

0 2 . 4 The spring in **Figure 5** was stretched inelastically.

What was the extension when the spring was at the limit of proportionality?

[2 marks]

Tick (✓) **one** box.

9 cm ☐   34 cm ☐   40 cm ☐

Give a reason for your answer.

____

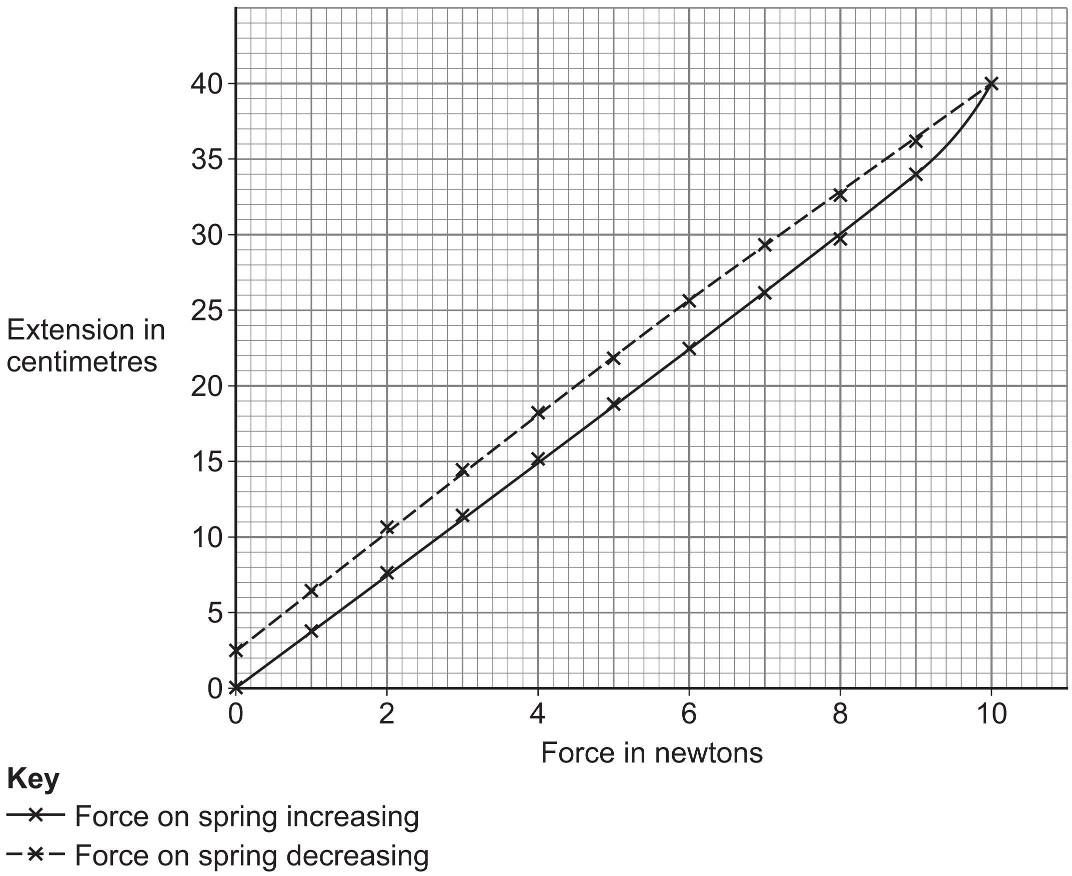
____

Question 2 continues on the next page

Do not write outside the box

0 2 . 5 **Figure 6** shows what happened to the extension of the spring as the force was decreased.

Figure 6



Describe what happened to the spring as the force was decreased from 10 N to 0 N.
[2 marks]

____

____

____

____

8

Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 3 This question is about ammonium chloride.

Ammonium chloride (NH_4Cl) decomposes to produce ammonia (NH_3) and hydrogen chloride (HCl).

The reaction is reversible.

The equation for the reaction is:

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

0 3 . 1 What is the state of hydrogen chloride in this reaction?

[1 mark]

Tick (✓) **one** box.

Aqueous ☐

Gas ☐

Liquid ☐

Solid ☐

0 3 . 2 How does the equation show that the reaction is reversible?

[1 mark]

____

____

Do not write outside the box

0 3 . 3 What is the total number of atoms in the formula NH_4Cl?

[1 mark]

Tick (✓) **one** box.

3 ☐ 4 ☐ 5 ☐ 6 ☐

0 3 . 4 When does a reversible reaction reach dynamic equilibrium?

[1 mark]

Tick (✓) **one** box.

When the forward reaction is slower than the reverse reaction. ☐

When the forward reaction and the reverse reaction have the same rate. ☐

When the forward reaction is faster than the reverse reaction. ☐

0 3 . 5 How must the apparatus for the reaction be designed so that dynamic equilibrium can be reached?

[1 mark]

Tick (✓) **one** box.

So all of the substances can escape. ☐

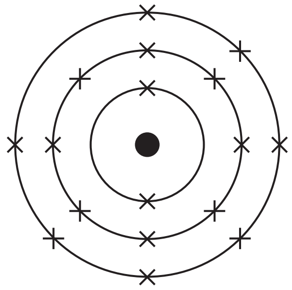
So none of the substances can escape. ☐

So only ammonia and hydrogen chloride can escape. ☐

Question 3 continues on the next page

0 3 . 6 **Figure 7** represents the electronic structure of a chlorine atom (Cl).

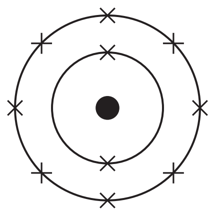
Figure 7

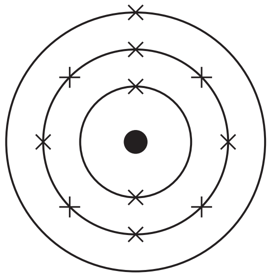


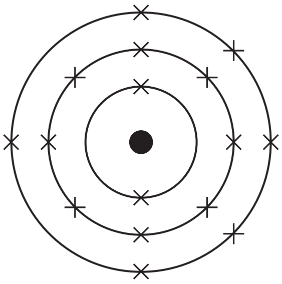
Which diagram represents the electronic structure of a chloride **ion** (Cl^-)?

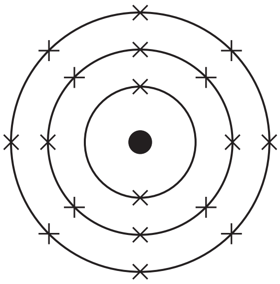
[1 mark]

Tick (✓) **one** box.









Do not write outside the box

0 3 . 7 Ammonia has the formula NH_3

Calculate the percentage (%) by mass of nitrogen (N) in NH_3

Relative atomic mass (A_r): N = 14

Relative formula mass (M_r): NH_3 = 17

Give your answer to 2 significant figures.

[3 marks]

____

____

____

____

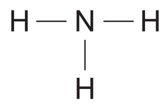
____

Percentage (2 significant figures) = ____________________ %

Question 3 continues on the next page

Figure 8 represents ammonia.

Figure 8



0 3 . 8 What does '—' represent in **Figure 8**?

[1 mark]

____

____

0 3 . 9 What type of particle is ammonia?

[1 mark]

Tick (✓) **one** box.

Atom ☐

Ion ☐

Molecule ☐

11

Do not write outside the box

Turn over for the next question

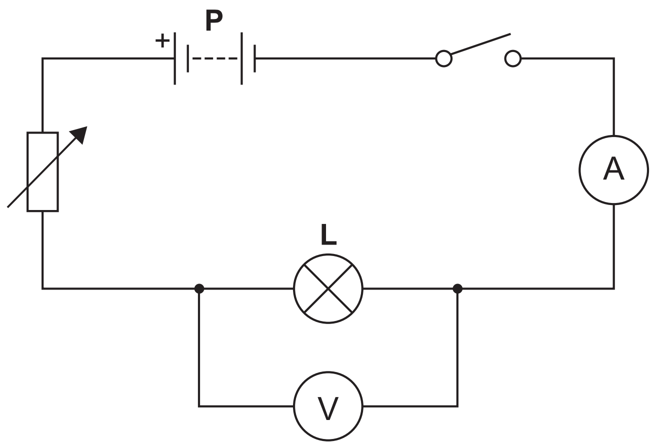
DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 4 Two students investigated how the current in filament lamp **L** varied with the potential difference across the lamp.

Figure 9 shows the circuit used.

Figure 9



0 4 . 1 What is component **P**?

[1 mark]

Tick (✓) **one** box.

Battery ☐

Cell ☐

Fuse ☐

Do not write outside the box

0 4 . 2 The resistance of the variable resistor is increased.

How does increasing the resistance of the variable resistor affect the reading on the ammeter?

[1 mark]

Tick (✓) **one** box.

The ammeter reading decreases. ☐

The ammeter reading stays the same. ☐

The ammeter reading increases. ☐

Question 4 continues on the next page

Figure 10 shows the results.

Figure 10

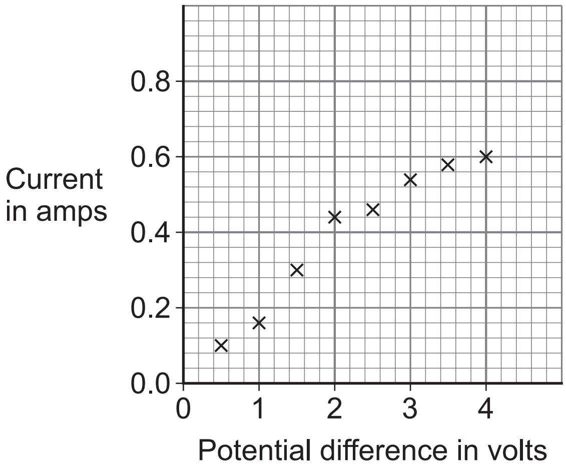
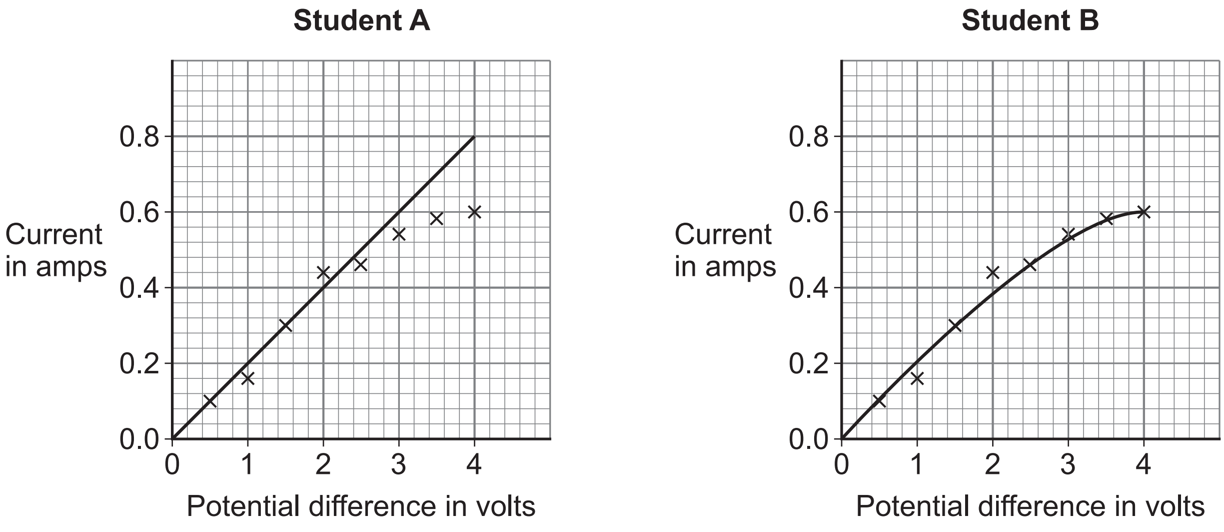


Figure 11 shows the line of best fit drawn by each student.

Figure 11



0 4 . 3 Explain why student **B**'s line of best fit is correct.

[2 marks]

____

____

____

____

0 4 . 4 What type of error will have caused the point at 2 V to be above the line of best fit?

[1 mark]

Tick (✓) **one** box.

A random error ☐

A systematic error ☐

A zero error ☐

Question 4 continues on the next page

0 4 . 5 When the potential difference across the filament lamp is 1.5 V, the current in the lamp is 0.3 A.

Calculate the resistance of the filament lamp.

Use the equation:

$$\text{resistance} = \frac{\text{potential difference}}{\text{current}}$$

[2 marks]

____

____

____

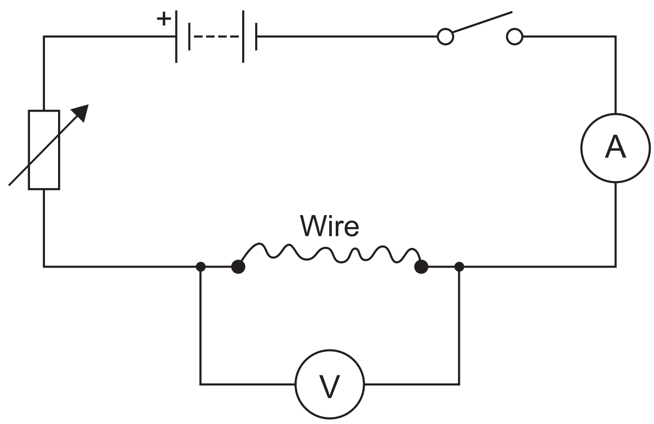
Resistance = ____________________ Ω

0 4 . 6 The students investigated how the length of a wire affects the resistance of the wire.

Figure 12 shows the circuit used.

The temperature of the wire was kept constant.

Figure 12



Identify the variables in the investigation.

[3 marks]

Tick (✓) **one** box in **each** row.

Variable	**Control variable**	**Dependent variable**	**Independent variable**
Length of the wire			
Resistance of the wire			
Temperature of the wire			

10

0 5 This question is about solutions.

0 5 . 1 0.4 dm^3 of a solution contains 24 g of solute.

Calculate the concentration of the solution.

Use the equation:

$$\text{concentration} = \frac{\text{mass of solute}}{\text{volume of solution}}$$

[2 marks]

____

____

____

Concentration = ____________________ g/dm^3

0 5 . 2 What is meant by a 'solute'?

[1 mark]

____

____

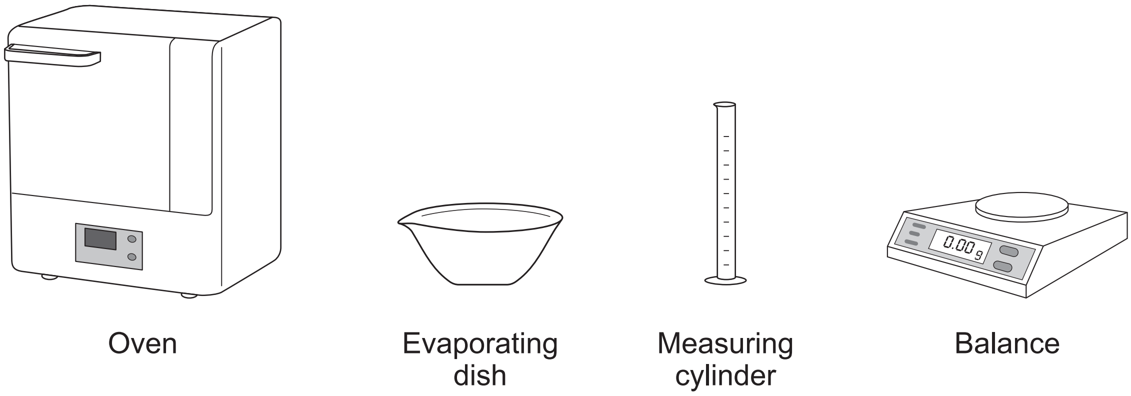
0 5 . 3 Sugar solution **X** and sugar solution **Y** have different concentrations.

A student investigated which solution had the higher concentration.

The student evaporated sugar solution at a temperature of 40 °C until only sugar remained.

Figure 13 shows the equipment used.

Figure 13



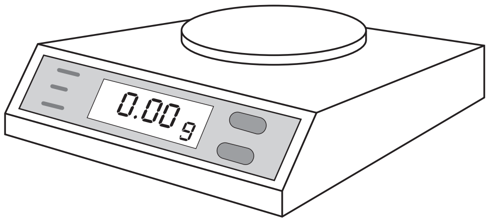
Plan a method to show if sugar solution **X** or sugar solution **Y** has the higher concentration.

[6 marks]

Question 5 continues on the next page

0 5 . 4 **Figure 14** shows the balance.

Figure 14



The resolution is the smallest change in the quantity being measured that a measuring instrument can show.

What is the resolution of the balance?

[1 mark]

Tick (✓) **one** box.

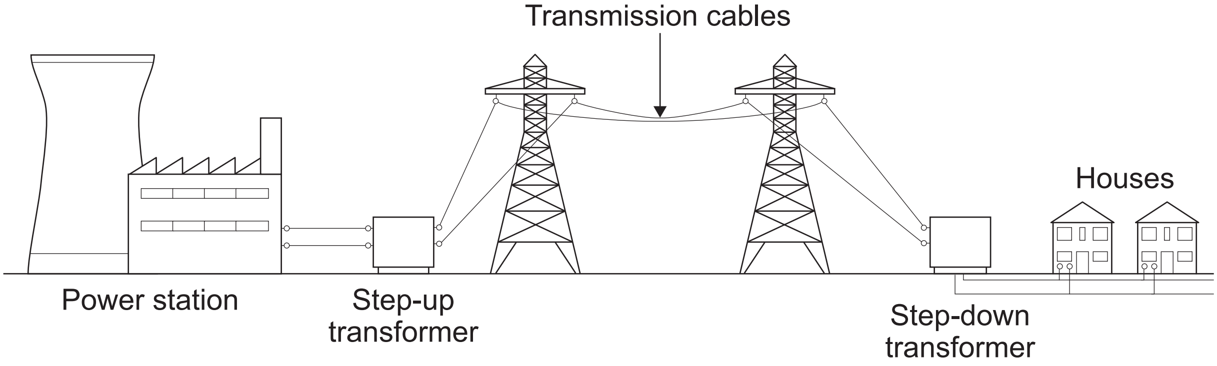
0.01 g ☐ 0.10 g ☐ 1.00 g ☐

10

Do not write outside the box

0 6 **Figure 15** shows how the National Grid connects a power station to houses.

Figure 15



The National Grid transfers electrical power efficiently from power stations to houses.

0 6 . 1 The step-down transformer supplies mains electricity to the houses.

Complete the sentence.

Choose the answer from the box.

[1 mark]

charge	**current**	**potential difference**	**resistance**

The step-down transformer decreases the ________________________________ .

Question 6 continues on the next page

Do not write outside the box

Figure 16 shows an electric kettle plugged into a socket in a house.

Figure 16

0 6 . 2 The cable connecting the kettle to the socket is a three-core cable.

The insulation on each wire is a different colour.

Draw **one** line from each wire to the colour of insulation.

[3 marks]

Wire	Colour of insulation
Earth	Blue
	Brown
Live	Green and yellow
	Purple
Neutral	Yellow and brown

Use the Physics Equations Sheet to answer questions **06.3** and **06.4**.

0 6 . 3 Which equation links charge flow (Q), energy (E) and potential difference (V)?

[1 mark]

Tick (✓) **one** box.

$E = \frac{Q}{V}$ ☐ $E = \frac{Q}{V^2}$ ☐ $E = Q^2V$ ☐ $E = QV$ ☐

0 6 . 4 The kettle is switched on to heat some water.

The energy transferred to the heating element in the kettle is 260 000 J.

The potential difference across the heating element is 1.3 V.

Calculate the charge flow in the heating element.

[3 marks]

____

____

____

____

____

Charge flow = ____________________ C

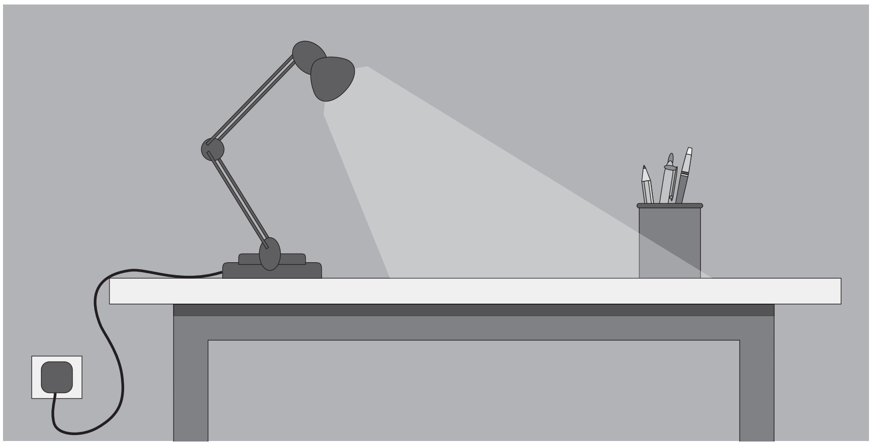
8

Turn over for the next question

Do not write outside the box

0 7 **Figure 17** shows a desk lamp connected to the mains electricity supply.

Figure 17



0 7 . 1 The desk lamp is fitted with a high-efficiency LED bulb.

What does 'high-efficiency' mean?

[1 mark]

Tick (✓) **one** box.

A large proportion of the total energy input is destroyed. ☐

A large proportion of the total energy input is usefully transferred. ☐

A large proportion of the total energy input is wasted. ☐

0 7 . 2 The LED bulb wastes energy as thermal energy.

How does the thermal energy affect the temperature of its surroundings?

[1 mark]

___

0 7 . 3 The output power of the lamp is 2.8 W.

Calculate the energy transferred by the lamp in 60 seconds.

Use the equation:

energy transferred = power × time

[2 marks]

___

___

___

Energy transferred = ____________ J

Question 7 continues on the next page

Do not write outside the box

0 7 . 4 Mains electricity can be dangerous.

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 pain in milliamps**	
	50 Hz ac supply	**10 000 Hz ac supply**
Mild pain	10	45
Moderate pain	15	65
Severe pain	20	80

ac is alternating current.

Compare the effects on the human body of 50 Hz ac with 10 000 Hz ac.

Use data from **Table 2**.

[4 marks]

____

____

____

____

____

____

____

____

8

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

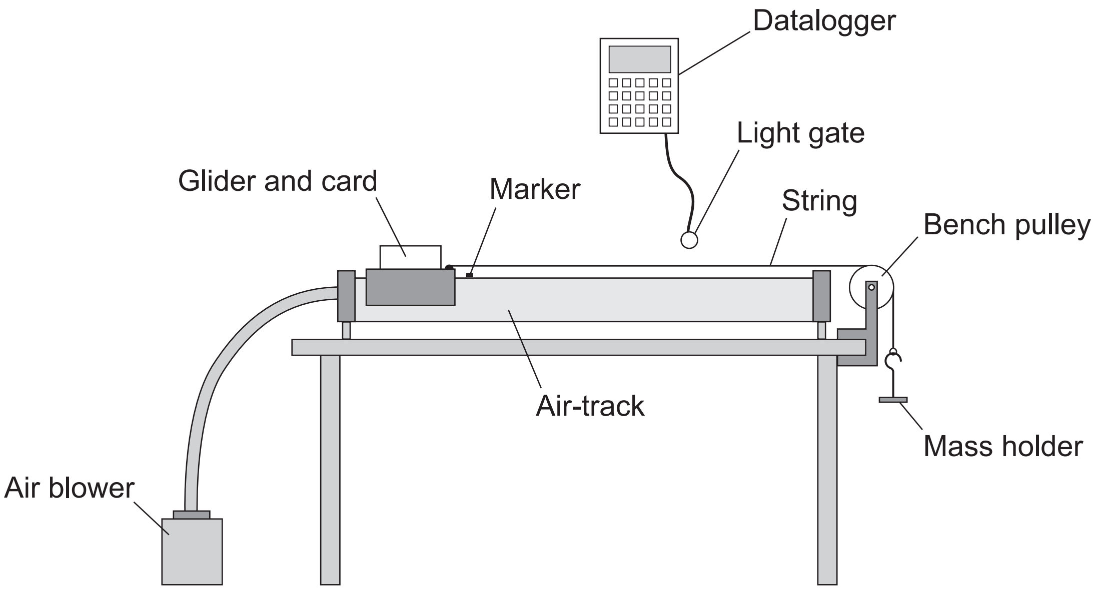
Turn over ▶

0 8 A student investigated how the acceleration of a glider varied with the force causing the acceleration.

Figure 18 shows the equipment used.

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

Figure 18



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. Repeat steps 1 to 3 using different masses on the mass holder.

The student calculated the weight of each mass to determine the force causing the acceleration.

0 8 . 1 Which measurements does the datalogger need to calculate the velocity of the glider?

[1 mark]

Tick (✓) **one** box.

The length of the card and the time taken to pass the light gate ☐

The length of the string and the length of the card ☐

The length of the string and the mass of the glider ☐

The mass of the glider and the time taken to pass the light gate ☐

Table 3 shows one set of results from the investigation.

Table 3

Mass on holder in kilograms	**Change in velocity in m/s**	**Time in seconds**
0.025	0.50	0.40

0 8 . 2 Calculate the acceleration of the glider.

Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

[2 marks]

____

____

____

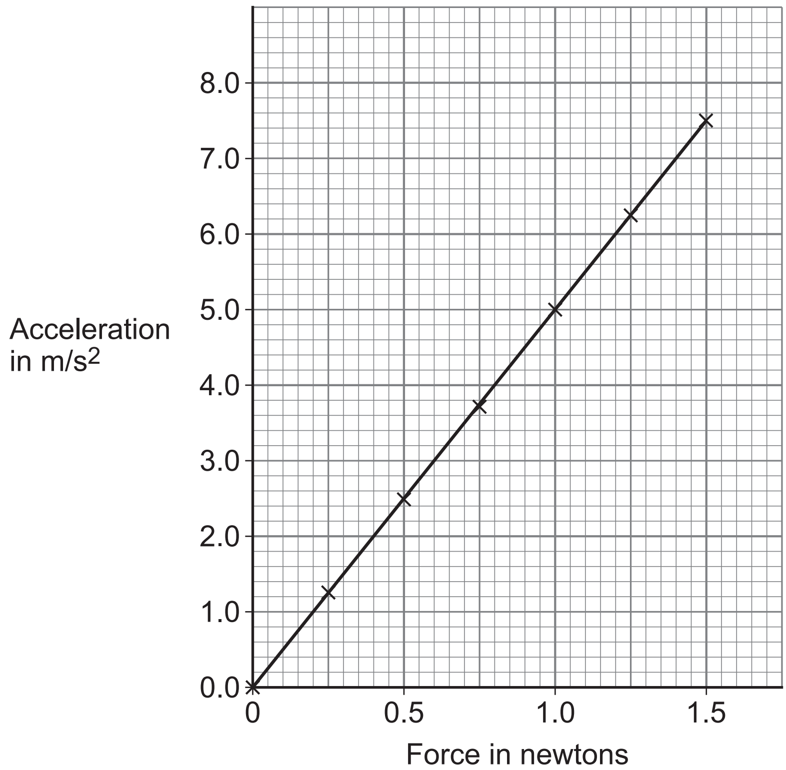
Acceleration = ____________________ m/s^2

Question 8 continues on the next page

Do not write outside the box

0 8 . 3 **Figure 19** shows the results.

Figure 19



What conclusion can the student make from the results in **Figure 19**?

Give a reason for your answer.

[2 marks]

Conclusion ____

____

Reason ____

____

Do not write outside the box

0 8 . 4 The 0.025 kg mass dropped through a height of 0.60 m.

Calculate the change in gravitational potential energy of this mass.

gravitational field strength = 9.8 N/kg

Use the equation:

gravitational potential energy = mass × gravitational field strength × height

[2 marks]

___

___

___

Change in gravitational potential energy = ____________________ J

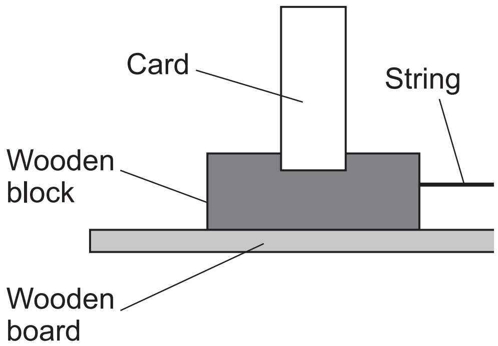
Question 8 continues on the next page

Do not write outside the box

0 8 . 5 Another student used a wooden block pulled along a wooden board instead of a glider on an air-track.

Figure 20 shows the wooden block.

Figure 20



How would the friction between the wooden block and the wooden board compare with the friction between the glider and the air-track?

[1 mark]

Tick (✓) **one** box.

The friction between the wooden block and the wooden board would be lower. ☐

The friction between the wooden block and the wooden board would be the same. ☐

The friction between the wooden block and the wooden board would be greater. ☐

8

Do not write outside the box

0 9 The stopping distance of a vehicle depends on the thinking distance and the braking distance.

0 9 . 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 **09.2** and **09.3**.

0 9 . 2 Write down the equation which links gravitational field strength (*g*), mass (*m*) and weight (*W*).

[1 mark]

____

0 9 . 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 9 continues on the next page

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

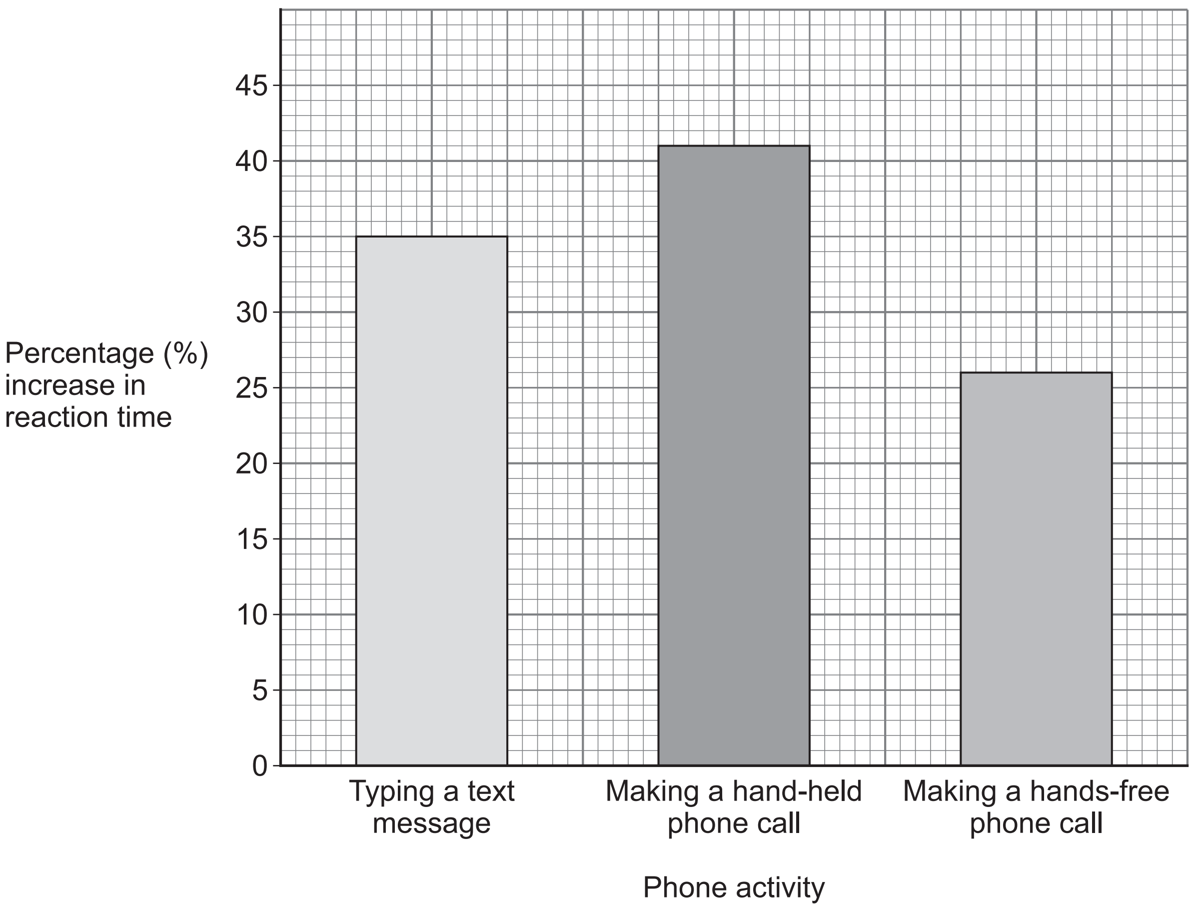
Using a mobile phone increases a driver's reaction time.

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

Figure 21



0 9 . 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 9 . 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 21** supports the student's suggestion.

[4 marks]

12

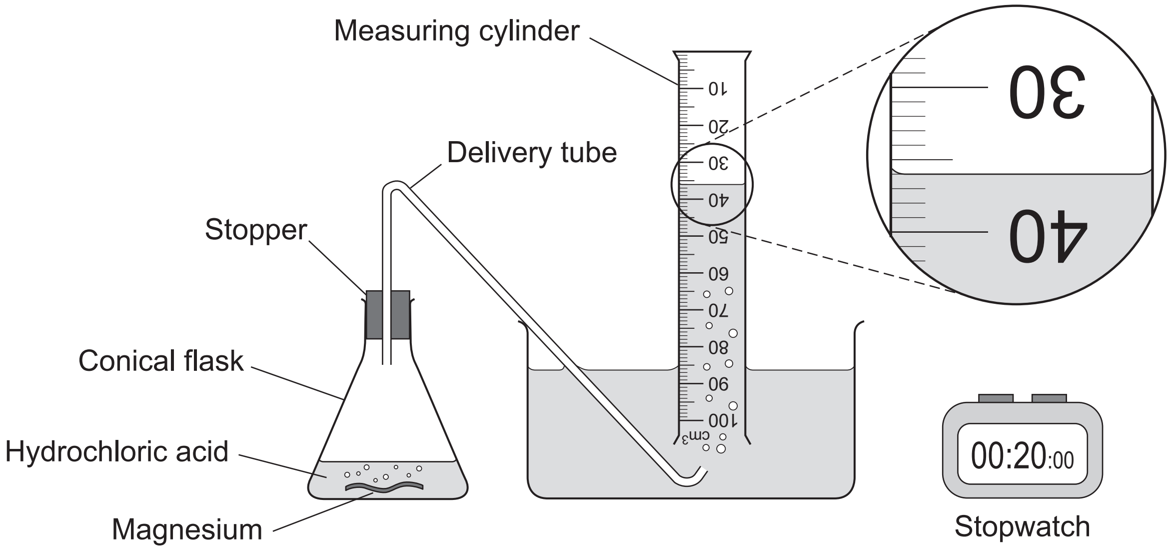
Do not write outside the box

1 0 Magnesium reacts with hydrochloric acid.

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

Figure 22 shows the apparatus.

Figure 22



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

1 0 . 1 What volume of hydrogen gas has been collected in the measuring cylinder in **Figure 22**?

[1 mark]

Volume = ____________________ cm^3

1 0 . 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]

____

____

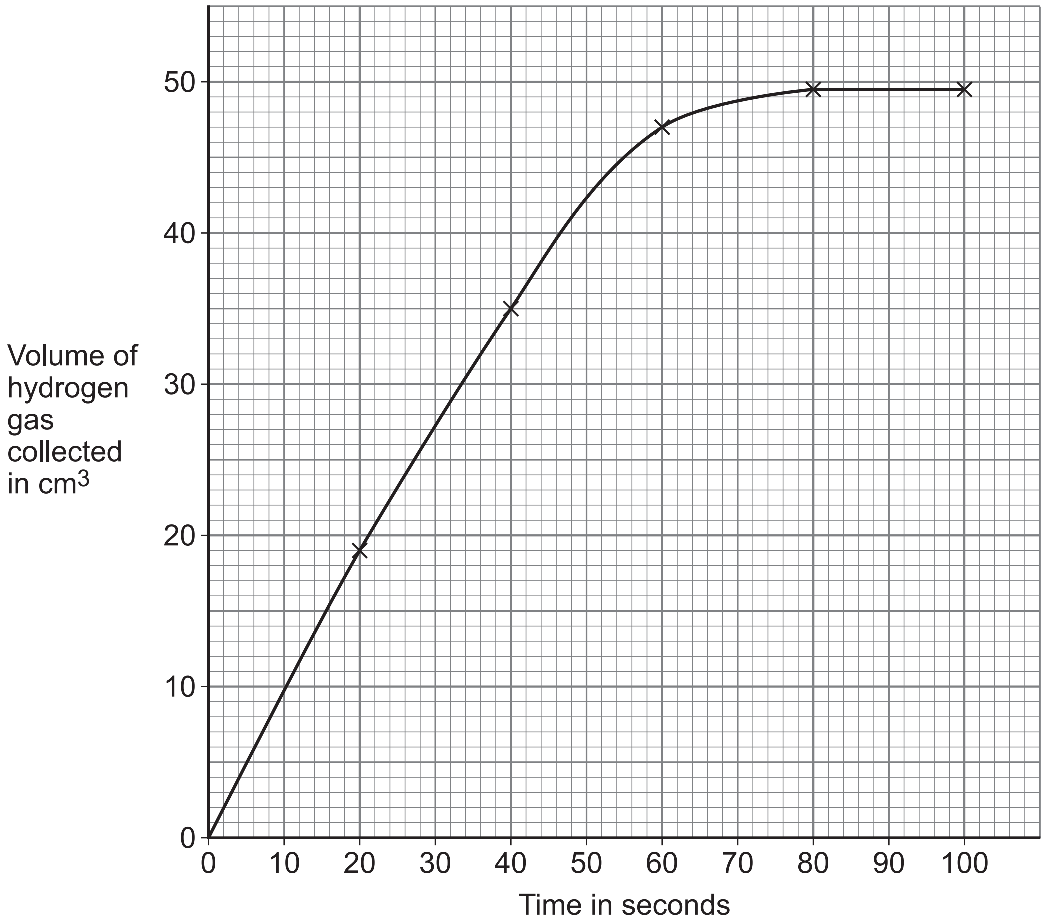
____

____

Question 10 continues on the next page

Figure 23 shows the results for one concentration of hydrochloric acid.

Figure 23



1 0 . 3 Determine the time taken for the reaction to be complete.

Use **Figure 23**.

[1 mark]

Time taken = ______________________ s

1 0 . 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 23**?

[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. ☐

1 0 . 5 Describe the test for hydrogen gas.

Give the result of the test.

[2 marks]

Test ____

____

Result ____

____

7

Turn over for the next question

1 1 A student investigated magnetic fields.

Figure 24 shows a cube-shaped magnet and a magnetic compass.

Figure 24

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

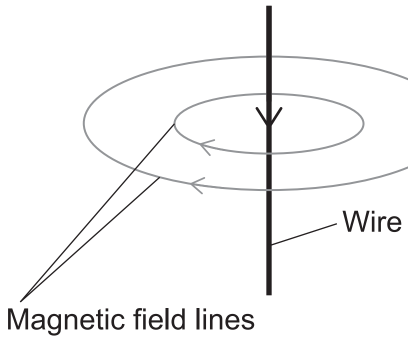
[2 marks]

Figure 25 shows a wire with a current in it.

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

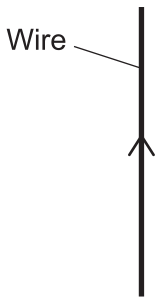
There is a magnetic field around the wire.

Figure 25



1 1 . 2 **Figure 26** shows the wire when the current is in the opposite direction to **Figure 25**.

Figure 26



Complete **Figure 26** to show the magnetic field around the wire.

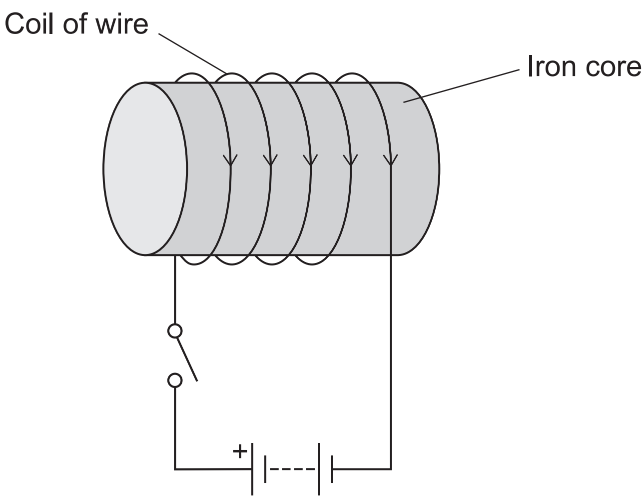
[1 mark]

Question 11 continues on the next page

Do not write outside the box

1 1 . 3 **Figure 27** shows an electromagnet made from a coil of wire wrapped around an iron core.

Figure 27



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

Label on **Figure 27**:

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

[1 mark]

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 **11.4** and **11.5**.

1 1 . 4 Write down the equation which links acceleration (*a*), mass (*m*) and resultant force (*F*).

[1 mark]

____

1 1 . 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

1 1 . 6 Explain why the acceleration of the paper clip changes as the paper clip moves towards the magnet.

[2 marks]

____

____

____

____

10

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.