AQA

Please write clearly in block capitals.

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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.

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0 1 **Figure 1** shows a steam engine pulling a train.

Figure 1



0 1 . 1 One type of steam engine burns coal as the fuel source.

The energy from the coal is used to accelerate a train.

Describe how the energy stores of the coal and the train change as the train accelerates.

[2 marks]

Do not write outside the box

0 1 . 2 Which equation links energy (E), power (P) and time (t)?

[1 mark]

Tick (✓) **one** box.

$E = \frac{P}{t}$ ☐ $P = \frac{E}{t}$ ☐ $P = Et^2$ ☐ $P = \frac{E^2}{t}$ ☐

0 1 . 3 A steam engine has a power output of 8000 W.

Calculate the energy output of the steam engine in 3600 seconds.

[3 marks]

Energy output = _____ J

0 1 . 4 In the 18th century the power output of steam engines was measured in a unit called 'horsepower'.

Suggest why the unit of horsepower was used.

[2 marks]

8

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0 2 This question is about the reaction between copper carbonate and nitric acid.

0 2 . 1 Carbon dioxide is produced when copper carbonate reacts with nitric acid.

Give the test for carbon dioxide gas.

Give the result of the test if carbon dioxide is present.

[2 marks]

Test _____

_____

Result _____

_____

0 2 . 2 The word equation for the reaction between copper carbonate and nitric acid is:

copper carbonate + nitric acid ⟶ **X** + **Y** + carbon dioxide

Name the products **X** and **Y**.

[2 marks]

X _____

Y _____

Do not write outside the box

A student investigated the rate of the reaction between copper carbonate and nitric acid.

0 2 . 3 Describe a method to show the effect of changing the temperature of the nitric acid on the rate of reaction.

Your method should include measuring the volume of carbon dioxide gas produced.

[6 marks]

Question 2 continues on the next page

Do not write outside the box

0 2 . 4 The student concluded that:

'An increase in temperature increases the rate of reaction.'

The student's conclusion was correct.

Explain why an increase in temperature increases the rate of reaction.

You should refer to particles and collisions in your answer.

[2 marks]

_____

_____

_____

_____

_____

_____

12

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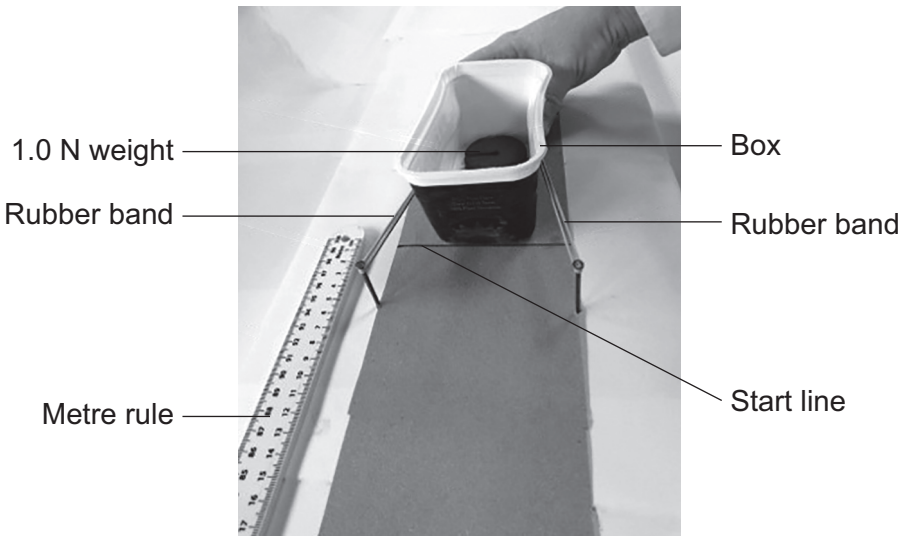
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ANSWER IN THE SPACES PROVIDED

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0 3 **Figure 2** shows the equipment a student used to investigate the effect of weight on the distance a box slides.

Figure 2



This is the method used.

1. Put a 1.0 N weight in the box.
2. Pull the box backwards until it reaches the start line, extending the rubber band by 10 cm.
3. Release the box.
4. When the box stops moving, measure the distance the box has slid using the metre rule.
5. Repeat steps 2 to 4 using a weight of 2.0 N and then 3.0 N.

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0 3 . 1 Identify the variables in the investigation.

[2 marks]

Independent variable _____

Dependent variable _____

0 3 . 2 The extension of the rubber band was a control variable in the investigation.

Suggest **one other** control variable in the investigation.

[1 mark]

_____

_____

0 3 . 3 **Table 1** shows the results when the weight inside the box was 1.0 N.

Table 1

Weight inside box in N	Distance the box slides in cm			
	Trial 1	Trial 2	Trial 3	Mean
1.0	12.6	13.1	13.4	13.0

What was the uncertainty in the distance measurements when the weight inside the box was 1.0 N?

[1 mark]

Tick (✓) **one** box.

±0.1 cm ☐ ±0.4 cm ☐ ±0.8 cm ☐ ±1.0 cm ☐

Question 3 continues on the next page

Do not write outside the box

0 3 . 4 The rubber band was extended by 10 cm.

The rubber band behaves like a spring with a spring constant of 36 N/m.

Calculate the elastic potential energy stored by the rubber band.

Use the Physics Equations Sheet.

[3 marks]

Elastic potential energy = _____ J

0 3 . 5 What is the maximum possible value for the kinetic energy of the box?

[1 mark]

Maximum possible kinetic energy = _____ J

Do not write outside the box

0 3 . 6 **Table 2** shows the student's results.

Table 2

Weight inside box in N	Distance the box slides in cm			
	Trial 1	Trial 2	Trial 3	Mean
1.0	12.6	13.1	13.4	13.0
2.0	10.4	9.4	10.0	9.9
3.0	7.9	7.3	6.8	7.3

Describe improvements the student could make to the method.

Use information from:

- **Figure 2**, on page 8
- **Table 2**.

[4 marks]

12

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0 4 Heating homes and businesses using natural gas produces a third of the UK's carbon dioxide emissions.

0 4 . 1 Give **one** energy resource that produces carbon dioxide when burnt.

Do **not** refer to natural gas.

[1 mark]

_____

0 4 . 2 Hydrogen can be burned to power cars.

Hydrogen can be extracted from seawater.

Burning 1 kg of hydrogen releases 142 MJ of energy.

Burning 1 kg of petrol releases 45 MJ of energy.

Give **two** advantages of using hydrogen to power cars compared with using petrol.

[2 marks]

1 _____

_____

2 _____

_____

Do not write outside the box

Scientists are investigating whether appliances that usually only burn natural gas can burn a mixture of hydrogen gas and natural gas.

0 4 . 3 Give **three** environmental benefits of burning a mixture of hydrogen gas and natural gas compared to just burning natural gas.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

0 4 . 4 All gas appliances in the UK bought since 1996 can burn a mixture of 23% hydrogen gas and 77% natural gas.

Explain a possible problem of changing the UK gas supply to this mixture of hydrogen gas and natural gas.

[2 marks]

_____

_____

_____

_____

8

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0 5 A student investigated the rate of the reaction between sodium thiosulfate solution and hydrochloric acid.

The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

0 5 . 1 Sulfur dioxide causes respiratory problems.

Suggest **one** precaution to reduce the risk of respiratory problems for the student.

[1 mark]

_____

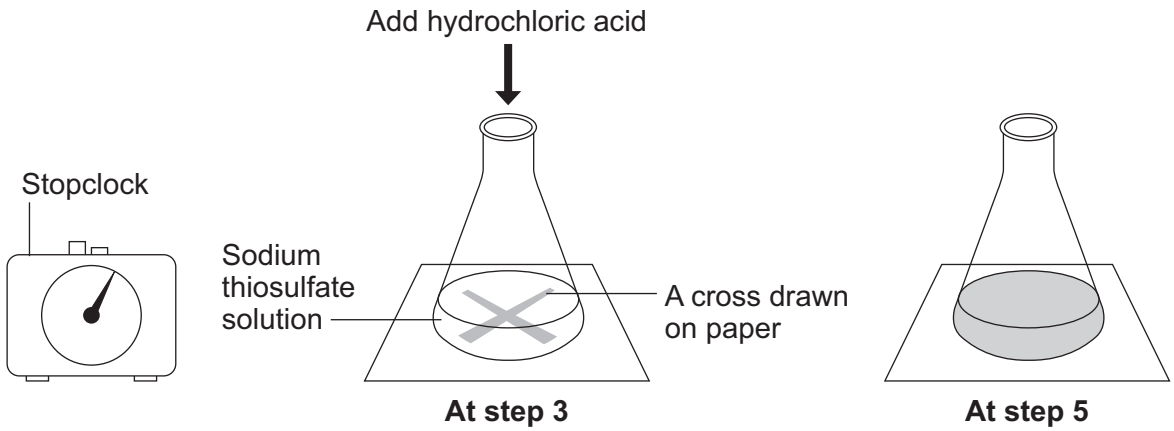
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This is the method used.

1. Add 50 cm^3 of sodium thiosulfate solution to a conical flask.
2. Put the conical flask on a piece of paper marked with a cross.
3. Add 5 cm^3 of hydrochloric acid and start timing with a stopclock.
4. Swirl the conical flask.
5. Stop the stopclock when the cross is no longer visible.
6. Repeat steps 1 to 5 for different concentrations of sodium thiosulfate solution.

Figure 3 shows the apparatus used.

Figure 3



Do not write outside the box

0 5 . 2 Explain why the cross is no longer visible.

Use the equation for the reaction to help you.

[3 marks]

0 5 . 3 Suggest **one** change to the method that would improve the accuracy of the results.

Give **one** reason why the change would improve the accuracy.

[2 marks]

Change _____

Reason _____

Question 5 continues on the next page

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0 5 . 4 **Table 3** shows the results.

Table 3

Concentration of sodium thiosulfate solution in g/dm^3	Time taken for cross to be no longer visible in seconds
8	120
16	74
24	52
32	36
40	26

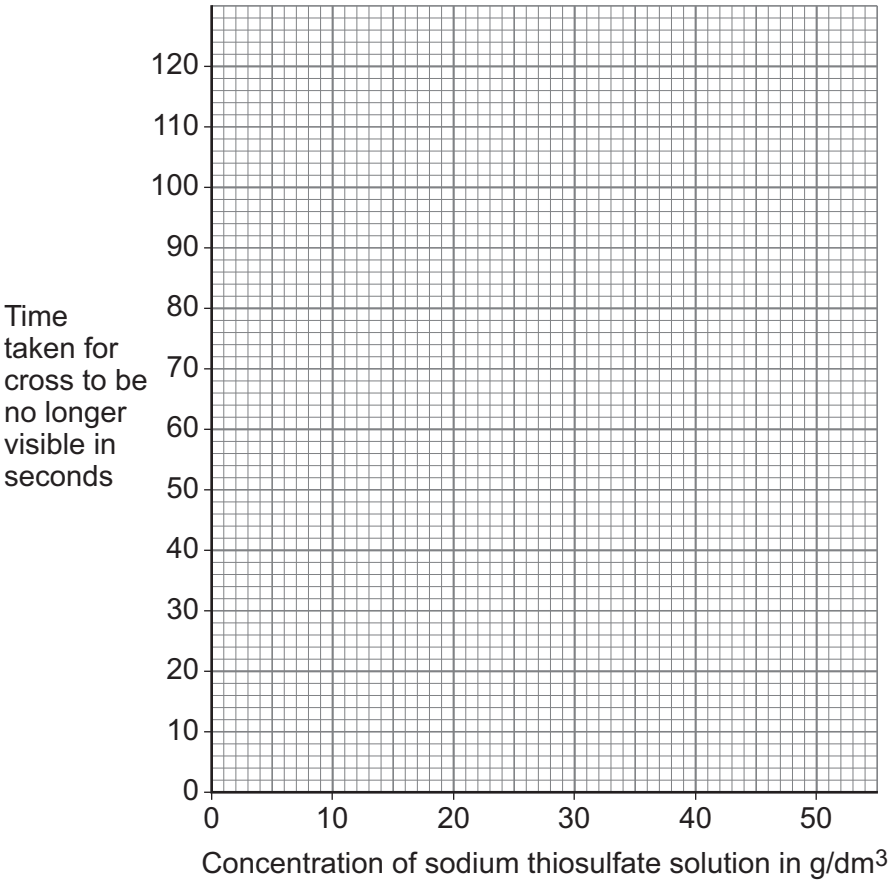
Plot the data from **Table 3** on **Figure 4**.

Draw a line of best fit.

[3 marks]

Do not write outside the box

Figure 4



0 5 . 5 Predict the time taken for the cross to be no longer visible for a 48 g/dm^3 sodium thiosulfate solution.

Use **Figure 4**.

[1 mark]

Time taken = _____ s

0 5 . 6 Give **one** conclusion about the effect of changing the concentration of sodium thiosulfate solution on the **rate** of reaction.

[1 mark]

_____

_____

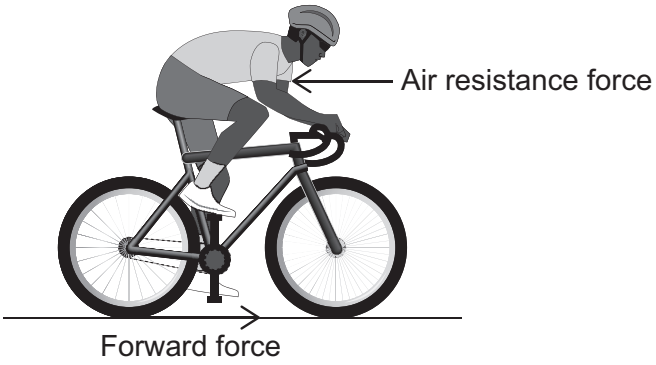
11

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0 6 **Figure 5** shows a cyclist on a straight, level road.

Figure 5



0 6 . 1 The cyclist's initial speed is zero.

The cyclist pushes on the pedals so that there is a constant forward force on the bike.

The force of air resistance increases as speed increases.

Explain why the speed of the cyclist reaches a maximum value.

[2 marks]

Do not write outside the box

0 6 . 2 The cyclist accelerates from 1.0 m/s to 5.0 m/s with an acceleration of 1.6 m/s^2.

Calculate the distance travelled during this acceleration.

[3 marks]

Distance = _____ m

0 6 . 3 In 2019 a cyclist broke a land speed record by cycling at a speed of 296 km/h.

Calculate the speed of the cyclist in m/s.

[3 marks]

Speed = _____ m/s

8

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ANSWER IN THE SPACES PROVIDED

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0 7 **Figure 6** shows a wind turbine.

Figure 6



0 7 . 1 An alternating potential difference is produced when the wind turbine spins.

What is meant by 'alternating potential difference'?

[1 mark]

_____

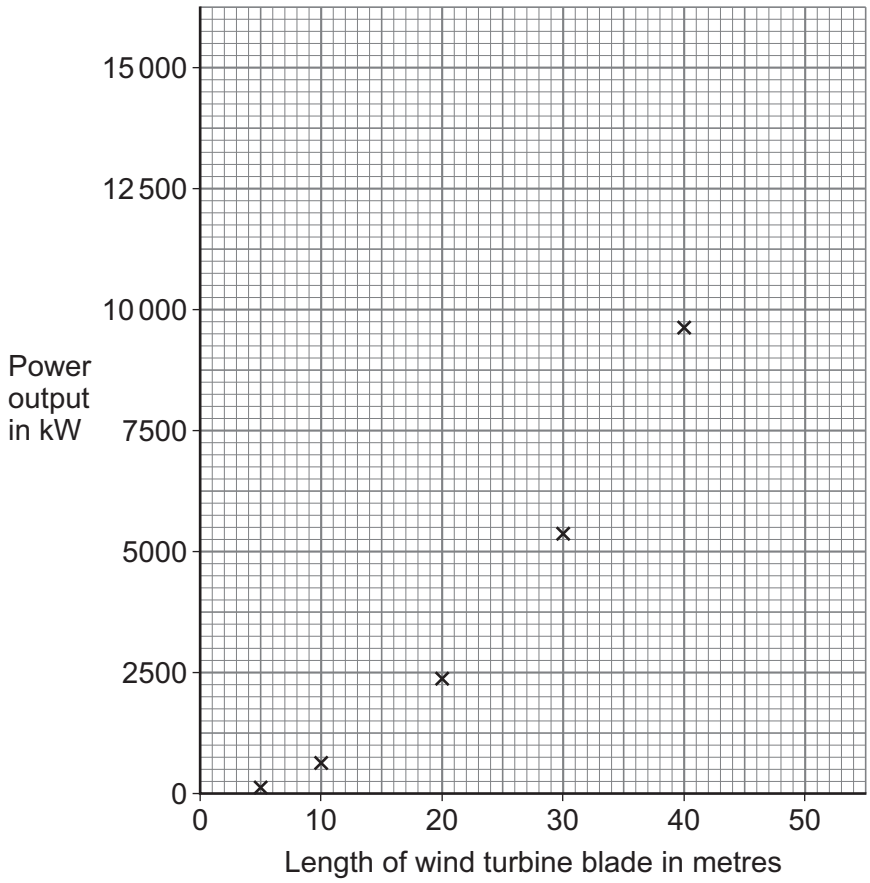
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Question 7 continues on the next page

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Figure 7 shows how the power output of a wind turbine varies with the length of the wind turbine blades when the wind speed is 20 m/s.

Figure 7



0 7 . 2 It is more economical to construct and use one wind turbine with 40-metre blades than two wind turbines with 20-metre blades.

Explain why.

Use information from **Figure 7**.

[2 marks]

Do not write outside the box

0 7 . 3 Predict the power output of a wind turbine with a blade length of 50 metres.

[1 mark]

Tick (✓) **one** box.

10 000 kW ☐

12 000 kW ☐

14 000 kW ☐

15 000 kW ☐

0 7 . 4 The kinetic energy of the air passing the wind turbine blades each second is 73.9 MJ.

The mass of air passing the wind turbine blades each second is 236 000 kg.

Calculate the speed of the air passing the wind turbine.

[4 marks]

Speed = _____ m/s

8

Turn over ▶

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0 8 Copper oxide reacts with sulfuric acid to produce copper sulfate.

0 8 . 1 What type of substance is copper oxide?

[1 mark]

Tick (✓) **one** box.

Acid ☐

Alkali ☐

Base ☐

Salt ☐

A student produced a pure, dry sample of copper sulfate crystals.

This is the first part of the method.

1. Measure 100 cm^3 of sulfuric acid into a beaker.
2. Gently warm the sulfuric acid.
3. Add 1.0 g of copper oxide powder to the sulfuric acid.
4. Stir the mixture.
5. Repeat steps 3 and 4 until the copper oxide is in excess.
6. Filter the mixture.

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0 8 . 2 Describe the additional steps needed to produce a pure, dry sample of copper sulfate crystals.

[4 marks]

0 8 . 3 The student added excess copper oxide.

Describe the steps that the student could include in the method to find the mass of copper oxide that reacted.

[5 marks]

Question 8 continues on the next page

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0 8 . 4 The student found that 2.4 g of copper oxide had reacted.

Copper oxide (CuO) is an ionic compound.

Calculate the total number of ions in 2.4 g of copper oxide.

Relative atomic masses (A_r): Cu = 63.5 O = 16

The Avogadro constant = 6.02×10^{23} per mole

[6 marks]

Total number of ions = _____

16

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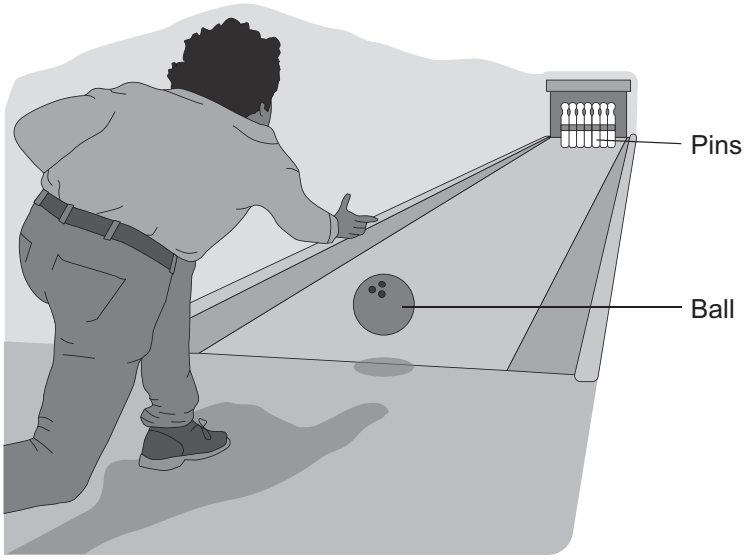
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0 9 Ten-pin bowling is a game where a ball is rolled along the floor to knock over some wooden pins.

Figure 8 shows a person ten-pin bowling.

Figure 8



Do not write outside the box

0 9 . 1 The person applied a mean force of 198 N to the ball for a time of 0.25 s.

The mass of the ball was 5.5 kg.

Calculate the velocity of the ball just after leaving the person's hand.

[5 marks]

Velocity = _____ m/s

0 9 . 2 The collision of the ball with the pins is an example of the conservation of momentum.

Explain how.

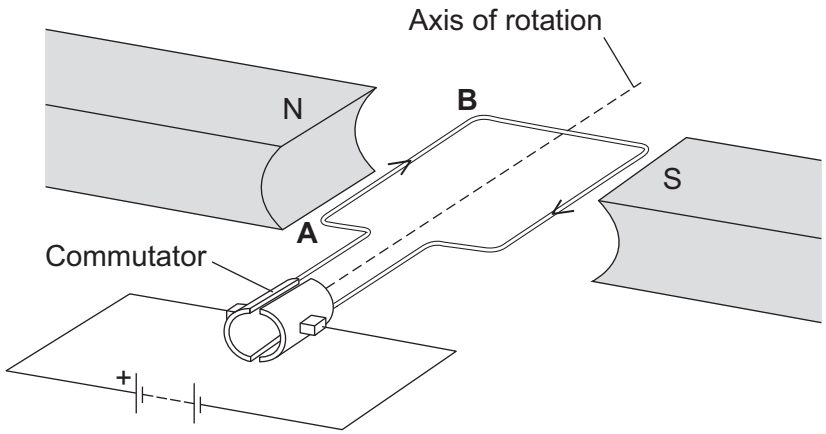
[2 marks]

7

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1 0 **Figure 9** shows a simple motor.

Figure 9



1 0 . 1 The force on the side of the coil of wire labelled **AB** is 0.102 N.

The current in the motor is 6.00 A.

The length of the side of the coil labelled **AB** in the magnetic field is 85.0 cm.

Calculate the magnetic flux density of the magnetic field between the magnets.

Give the unit.

[5 marks]

Magnetic flux density = _____

Unit _____

Do not write outside the box

1 0 . 2 The direction of the force on the side of the coil of wire **AB** changes as the coil rotates.

Explain why.

[3 marks]

1 0 . 3 Explain what would happen to the coil if the commutator is removed and the coil is connected directly to the wires of the circuit.

[2 marks]

10

END OF QUESTIONS

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