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 3 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	
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

0 1 This question is about structure and bonding.

0 1 . 1 Why can metals be shaped?

[1 mark]

Tick (✓) **one** box.

Different-sized atoms distort the structure. ☐

Layers of atoms slide over each other. ☐

Metallic bonds are weak. ☐

Metals have low melting points. ☐

0 1 . 2 Explain how metals conduct electricity.

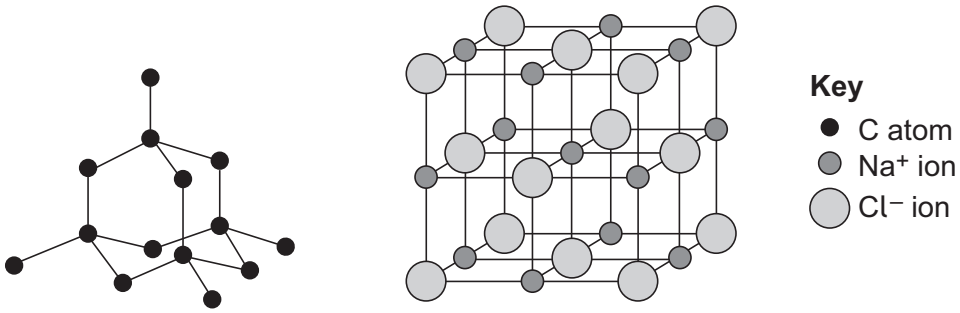
You should answer in terms of electrons.

[3 marks]

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0 1 . 3 **Figure 1** represents the structure of diamond and of sodium chloride.

Figure 1



Diamond **Sodium chloride**

Compare the structure and bonding of diamond with the structure and bonding of sodium chloride.

[6 marks]

Question 1 continues on the next page

Do not write outside the box

Ethene (C_2H_4) is a small molecule.

0 1 . 4 Calculate the relative formula mass (M_r) of ethene.

Relative atomic masses (A_r): C = 12 H = 1

[2 marks]

Relative formula mass = _____

0 1 . 5 Ethene molecules join together to form long-chain poly(ethene) molecules.

Explain why poly(ethene) has a higher melting point than ethene.

You should refer to the:

- size of the molecules
- intermolecular forces.

[3 marks]

15

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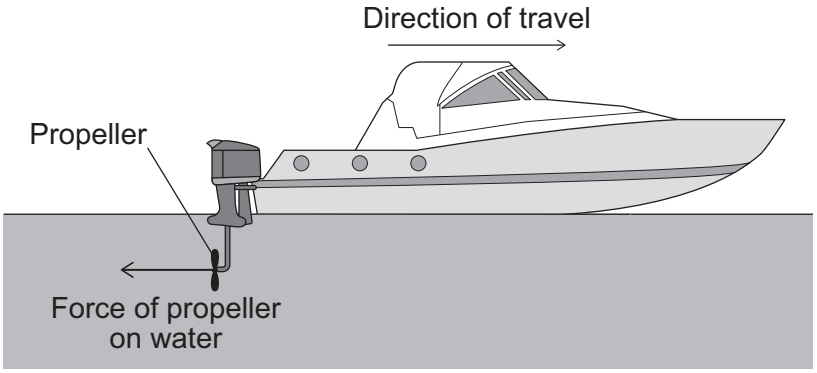
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ANSWER IN THE SPACES PROVIDED

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0 2 **Figure 2** shows a boat on the sea.

Figure 2



The boat is travelling at a constant speed.

0 2 . 1 Draw an arrow on **Figure 2** to show the size and direction of the force of the water on the propeller.

[2 marks]

0 2 . 2 A quantity can be a scalar quantity or a vector quantity.

Identify which quantities are scalar quantities and which quantities are vector quantities.

[2 marks]

Tick (✓) **one** box in **each** row.

Quantity	Scalar	Vector
Speed		
Velocity		
Mass		
Weight		

Do not write outside the box

0 2 . 3 Which equation links distance (s), speed (v) and time (t)?

[1 mark]

Tick (✓) **one** box.

$s = \frac{v}{t}$ ☐ $s = \frac{t}{v}$ ☐ $v = \frac{s}{t}$ ☐ $v = s \times t$ ☐

0 2 . 4 The speed of the boat is 12 m/s.

Calculate the time taken to travel 6000 m.

Use the Physics Equations Sheet.

[3 marks]

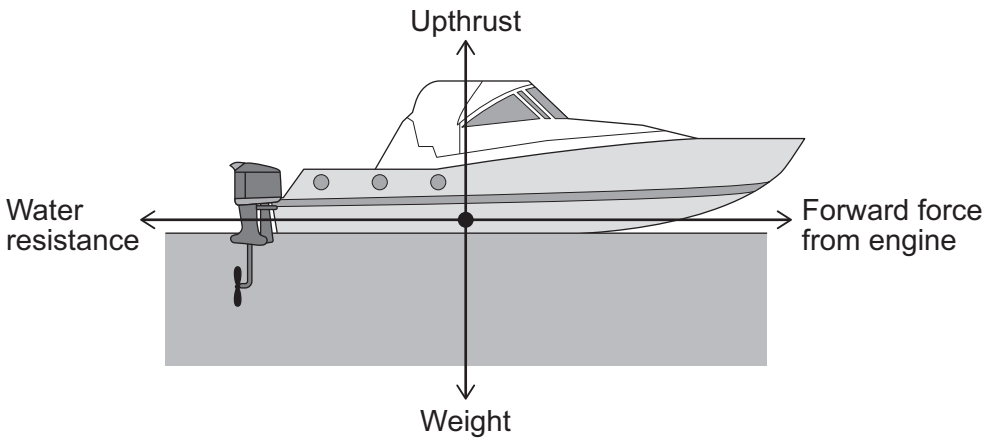
Time = _____ s

Question 2 continues on the next page

Do not write outside the box

0 2 . 5 **Figure 3** shows the forces acting on the boat when it is moving at a constant speed.

Figure 3



The engine of the boat is turned off. The boat slows down and stops.

Explain what happens to the forces acting on the boat.

[6 marks]

14

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0 3 Calcium carbonate reacts with hydrochloric acid.

The equation for the reaction is:

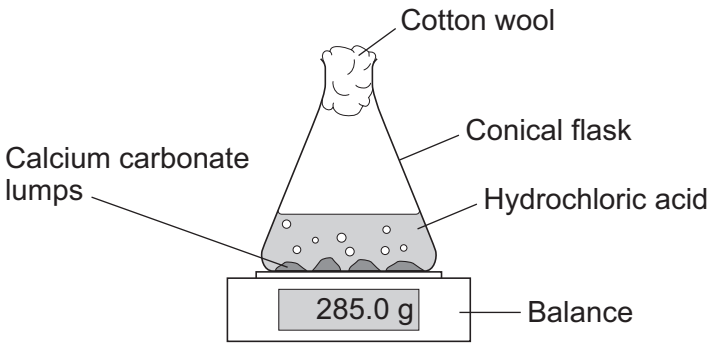
$$CaCO_3(s) + 2\,HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

A student investigated the effect of changing the surface area of the calcium carbonate on the rate of this reaction.

The student used calcium carbonate in the form of lumps and of powder.

Figure 4 shows the apparatus.

Figure 4



The rate of reaction is determined by measuring the decrease in mass of the conical flask and contents at regular time intervals.

0 3 . 1 Give the reason why the mass of the conical flask and contents decreases.

[1 mark]

_____

_____

Do not write outside the box

0 3 . 2 The mean rate of reaction using the calcium carbonate lumps was 0.0012 g/s.

Calculate the time taken for the mass of the conical flask and contents to decrease by 0.36 g.

[3 marks]

Time taken = _____ s

0 3 . 3 The results showed that calcium carbonate powder reacted faster than calcium carbonate lumps.

Explain why calcium carbonate powder reacted faster than calcium carbonate lumps.

[3 marks]

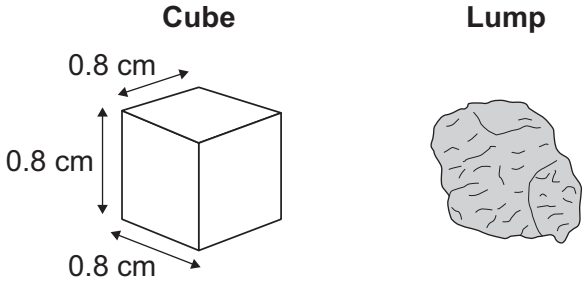
Question 3 continues on the next page

Do not write outside the box

The surface area of a calcium carbonate lump can be estimated by comparing the lump with a cube.

Figure 5 shows a cube and a similar-sized calcium carbonate lump.

Figure 5



0 3 . 4 Calculate the total surface area of the cube in **Figure 5**.

[3 marks]

Total surface area = _____ cm^2

0 3 . 5 The total surface area of the calcium carbonate lump in **Figure 5** is estimated rather than measured.

Suggest **one** reason why.

[1 mark]

11

Do not write outside the box

0 4 Hydrogen reacts with oxygen to produce water.

Figure 6 represents the equation for the reaction.

Figure 6

$$2H{-}H + O{=}O \rightarrow 2H{-}O{-}H$$

Table 1 shows bond energies.

Table 1

Bond	Bond energy in kJ/mol
H—H	436
O=O	498
O—H	464

0 4 . 1 Calculate the energy released during bond formation in the reaction.

Use **Figure 6** and **Table 1**.

[2 marks]

_____

_____

_____

_____

Energy released = _____ kJ/mol

Question 4 continues on the next page

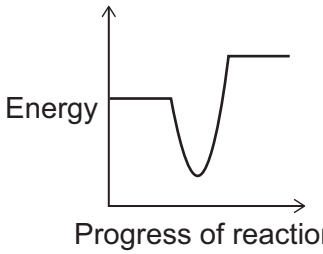
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0 4 . 2 In the reaction to produce water, the energy needed to break bonds is less than the energy released when bonds are formed.

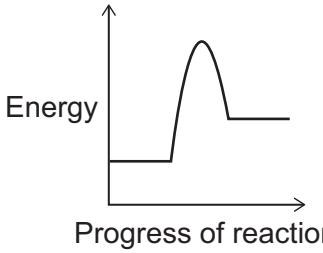
Which reaction profile represents this reaction?

[1 mark]

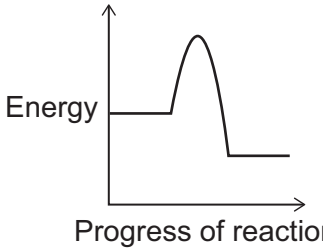
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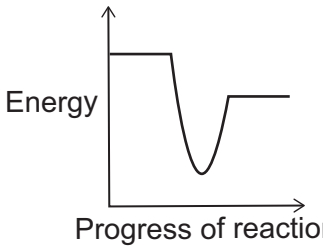
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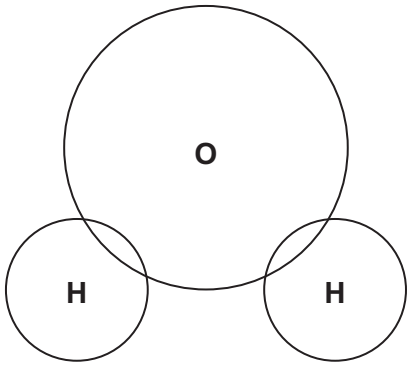


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0 4 . 3 Complete the dot and cross diagram for a water molecule.

[2 marks]



0 4 . 4 Explain why hydrogen gas (H_2) consists of molecules rather than single atoms.

[3 marks]

_____

_____

_____

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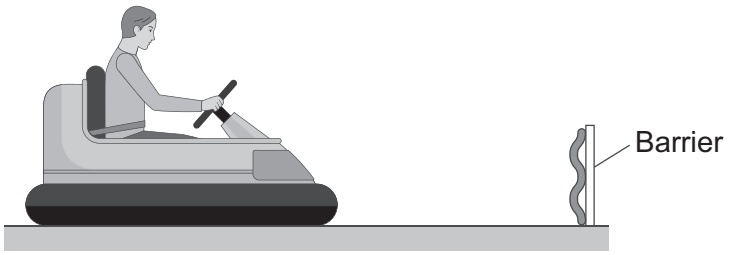
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Turn over for the next question

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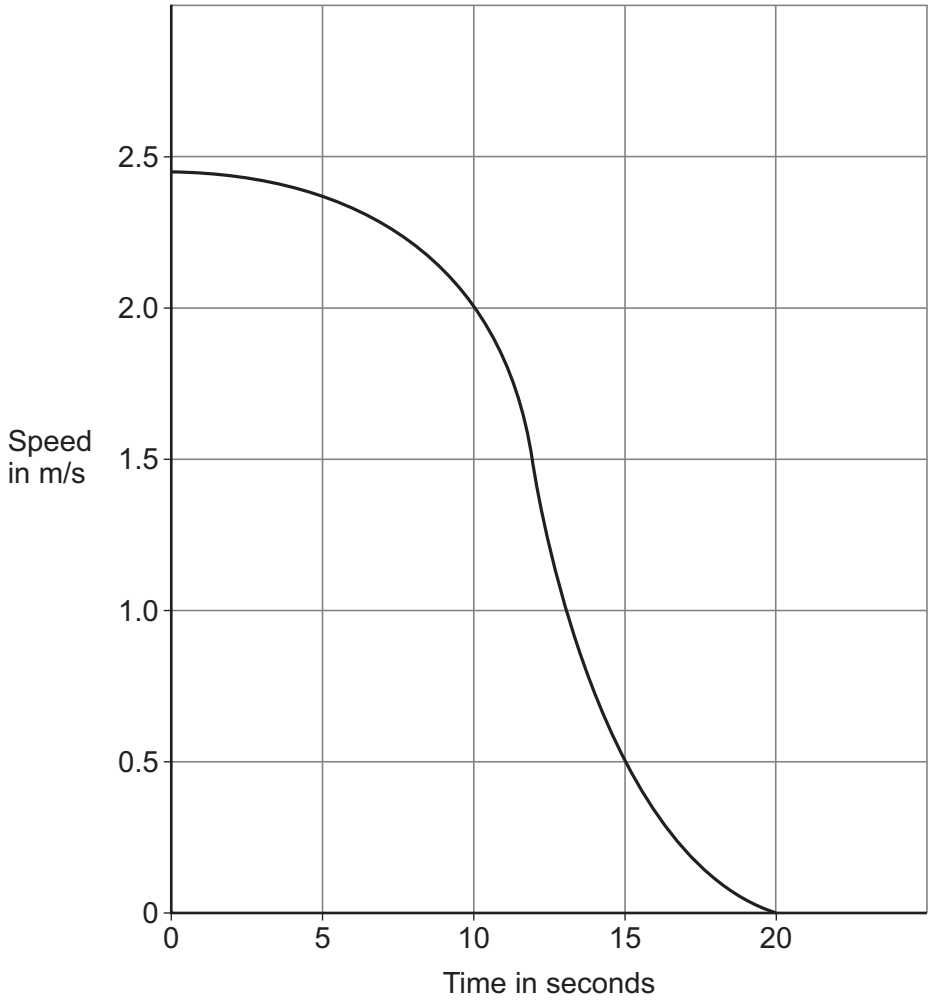
0 5 **Figure 7** shows a student driving a bumper car at a theme park.

Figure 7



0 5 . 1 **Figure 8** shows how the speed of the bumper car changed during a time of 20 seconds.

Figure 8



Do not write outside the box

Estimate the distance travelled by the bumper car during the 20 seconds.

[3 marks]

Distance = _____ m

0 5 . 2 The bumper car motor has an efficiency of 80%.

The useful power output of the motor is 220 W.

Calculate the total power input to the motor.

Use the Physics Equations Sheet.

[4 marks]

Total power input = _____ W

Question 5 continues on the next page

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0 5 . 3 A bumper car collides with a stationary barrier and stops.

The student is wearing a seatbelt.

Explain how the seatbelt stops the student moving.

[3 marks]

0 5 . 4 When the bumper car collided with the barrier, the bumper car came to a stop in a time of 600 ms.

The deceleration of the student was 2.0 m/s^2.

Calculate the initial velocity of the student.

Use the Physics Equations Sheet.

[4 marks]

Initial velocity = _____ m/s

14

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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 This question is about the extraction of metals.

0 6 . 1 Name the process that uses bacteria to extract metals.

[1 mark]

_____

0 6 . 2 Iron can be extracted from iron oxide using carbon.

The word equation for the reaction is:

iron oxide + carbon → iron + carbon dioxide

Explain why this reaction is both oxidation **and** reduction.

[2 marks]

_____

_____

_____

_____

0 6 . 3 Give **one** reason why some metals cannot be extracted from their oxides using carbon.

[1 mark]

_____

_____

Do not write outside the box

0 6 . 4 Aluminium is manufactured by the electrolysis of a molten mixture of aluminium oxide and cryolite.

Explain why cryolite is used.

[2 marks]

_____

_____

_____

_____

0 6 . 5 Aluminium is produced at the negative electrode.

Complete the half equation for the reaction.

You should balance the equation.

[2 marks]

Al^{3+} + _____ → _____

8

Turn over for the next question

Do not write outside the box

0 7 This question is about chemical quantities.

0 7 . 1 0.40 dm^3 of a solution contains 48.4 g of solute.

Calculate the concentration of the solution.

Give the unit.

[3 marks]

Concentration of solution = _____ Unit _____

0 7 . 2 Calculate the number of carbon dioxide molecules in 3.00 moles of carbon dioxide.

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

Give your answer to 3 significant figures.

[3 marks]

Number of molecules (3 significant figures) = _____

Do not write outside the box

0 7 . 3 Metal **M** forms a metal oxide with the formula $\mathbf{M_2O_3}$

The relative formula mass of the metal oxide is 152.

Determine the identity of metal **M**.

Relative atomic mass (A_r): O = 16

[4 marks]

Metal **M** = _____

10

Turn over for the next question

Do not write outside the box

0 8 This question is about the periodic table.

0 8 . 1 The halogens are in Group 7 of the periodic table.

Explain the trend in reactivity going down Group 7.

[4 marks]

0 8 . 2 Explain how the electronic structure of calcium relates to calcium reacting as a metal.

[2 marks]

Do not write outside the box

0 8 . 3 Rubidium has an atomic number of 37.

Complete the equation for the reaction of rubidium with water.

You should balance the equation.

Use the periodic table.

[3 marks]

9

____ Rb + ____ H_2O → _____ + _____

Turn over for the next question

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0 9 A normal bicycle can be converted into an electric bicycle.

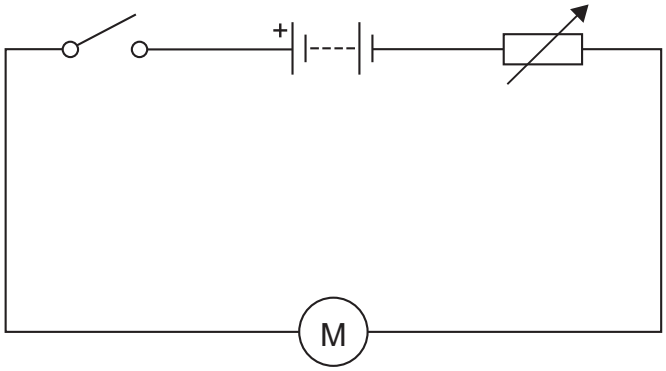
Figure 9 shows a converted bicycle.

Figure 9



Figure 10 shows the circuit diagram for the bicycle.

Figure 10



The circuit symbol for a motor is: (M)

Do not write outside the box

0 9 . 1 The switch is used to turn the motor on or off.

Explain how the variable resistor is used to control the speed of the motor.

[3 marks]

Question 9 continues on the next page

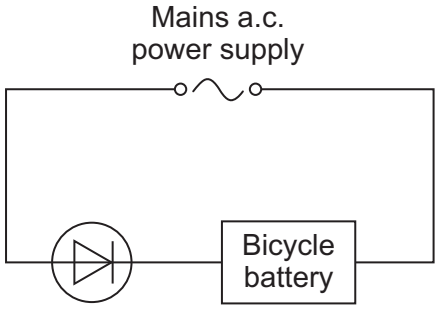
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The battery can be recharged using the mains electricity supply.

0 9 . 2 The mains supply is alternating current.

Figure 11 shows a simplified version of the circuit that is used to recharge the battery.

Figure 11



Explain why charge only passes in one direction through the circuit.

[3 marks]

Do not write outside the box

0 9 . 3 The mains supply fully recharged the battery in 2 hours.

The mean charging current was 5.0 A.

The resistance of the battery was 0.18 Ω.

Calculate the energy dissipated due to the resistance of the battery in 2 hours.

Use the Physics Equations Sheet.

[5 marks]

Energy dissipated = _____ J

11

END OF QUESTIONS

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