Please write clearly in block capitals.

Centre number

Candidate number

Surname

Forename(s)

Candidate signature

GCSE

COMBINED SCIENCE: SYNERGY

Higher Tier  Paper 4  Physical sciences

Wednesday 13 June 2018  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.
• 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.
• 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.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
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<td>5</td>
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<td>6</td>
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<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
</tbody>
</table>
A light dependent resistor (LDR) is connected in a circuit.

Draw the circuit symbol for an LDR.

A student investigated the relationship between current and potential difference for an LDR.

How should the student have connected the ammeter and voltmeter in the circuit?

Tick one box.

<table>
<thead>
<tr>
<th>Ammeter</th>
<th>Voltmeter</th>
</tr>
</thead>
<tbody>
<tr>
<td>in parallel with LDR</td>
<td>in parallel with LDR</td>
</tr>
<tr>
<td>in parallel with LDR</td>
<td>in series with LDR</td>
</tr>
<tr>
<td>in series with LDR</td>
<td>in parallel with LDR</td>
</tr>
<tr>
<td>in series with LDR</td>
<td>in series with LDR</td>
</tr>
</tbody>
</table>

Question 1 continues on the next page
Figure 1 shows a sketch graph of the student’s results.

The LDR was in a constant bright light.

Figure 1

The student concluded that the current in the LDR is inversely proportional to the potential difference across the LDR.

Explain why the student’s conclusion is incorrect.

[2 marks]

The student repeated the investigation with the LDR in constant dark conditions.

Sketch on Figure 1 the graph for the LDR in constant dark conditions.

[2 marks]
The LDR was placed near a light source.

The following results were recorded:

potential difference = 5.50 V

current = 12.5 mA

Write down the equation that links current, potential difference and resistance. [1 mark]

Calculate the resistance of the LDR. [4 marks]

Resistance = ________ Ω
Supermarket carrier bags can be made from poly(ethene).

Poly(ethene) is produced from ethene.

The structure of ethene is:

\[
\begin{array}{c}
  \text{H} \\
  \text{\_\_\_\_C} \\
  \text{\_\_\_\_H}
\end{array}
\]

Complete the structure of poly(ethene).

\[
\left( \begin{array}{c} 
  \text{H} \\
  \text{\_\_\_C} \\
  \text{\_\_\_H} \\
\end{array} \right)^n
\]
There are two types of poly(ethene): HD poly(ethene) and LD poly(ethene).

Figure 2 shows the polymer chains in HD poly(ethene) and LD poly(ethene).

**Figure 2**

![Diagram showing HD and LD poly(ethene)]

Describe the differences in the structure and arrangement of the polymer chains in the two types of poly(ethene).

[2 marks]

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Question 2 continues on the next page
A student investigated how poly(ethene) extends when a force is applied.

**Describe a method to investigate how the extension of poly(ethene) changes with the force applied.**

**[4 marks]**

---

**Figure 3** shows the results for HD poly(ethene) and LD poly(ethene).
02.4 Give two comparisons between the results for HD poly(ethene) and for LD poly(ethene).

Use Figure 3. [2 marks]

1


2


02.5 Carrier bags in supermarkets used to be provided free. Supermarkets now make customers pay for carrier bags.

When they were free, 8.0 billion new carrier bags were used each year.

After supermarkets started making customers pay for carrier bags, the use of new bags dropped by 85%

Calculate how many carrier bags are now used each year. [2 marks]

Number of bags =


Question 2 continues on the next page
There are two types of carrier bag in common use:

- disposable bags
- bags for life.

Bags for life can be returned to the supermarket when no longer usable.

The supermarket replaces the bag for life free of charge and arranges for the bag to be recycled.

**Table 1** shows data from a life cycle assessment (LCA) for the two types of carrier bag.

<table>
<thead>
<tr>
<th></th>
<th>Disposable bag</th>
<th>Bag for life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of polymer</td>
<td>HD poly(ethene)</td>
<td>LD poly(ethene)</td>
</tr>
<tr>
<td>Raw material from which polymer is made</td>
<td>Crude oil</td>
<td>Crude oil</td>
</tr>
<tr>
<td>Mass of waste material per bag from production in grams</td>
<td>0.42</td>
<td>0.17</td>
</tr>
<tr>
<td>Mass of carbon dioxide emitted per bag during production and transport in grams</td>
<td>1.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Mean number of times used</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Possible disposal methods</td>
<td>Landfill Incineration Recycling</td>
<td>Landfill Incineration Recycling</td>
</tr>
</tbody>
</table>
Evaluate the use of each type of carrier bag.

Use data from Table 1 and your own knowledge.

[6 marks]

Turn over for the next question
Forces are vector quantities.

What is the difference between a vector quantity and a scalar quantity? [2 marks]

Figure 4 represents a wooden block being pulled across a surface at a constant speed in a straight line.

The block is in contact with the surface.

The arrow in Figure 4 represents the tension force in the string pulling the block.

Figure 4

Complete Figure 4 to show the other three forces acting on the block. [3 marks]
**Figure 5** is a copy of **Figure 4** to help you answer the following question.

**Figure 5**

![Diagram of a wooden block on a carpet with tension force and string](image)

**033** Figure 5 is drawn to scale. The scale is 1 cm : 0.5 N

Determine the horizontal and vertical components of the tension in the string.

Show these components on **Figure 5**.

[3 marks]

Horizontal component = ___________ N

Vertical component = ___________ N

Question 3 continues on the next page
A student collects data on the size of the force required to pull the block across different surfaces at a constant speed.

Table 2 shows the results.

<table>
<thead>
<tr>
<th>Type of surface</th>
<th>Force in N</th>
<th>Mean force in N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Cardboard</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Carpet</td>
<td>2.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Glass</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Sandpaper</td>
<td>5.2</td>
<td>X</td>
</tr>
</tbody>
</table>

Calculate value X in Table 2.

X = ________ N

Give three control variables for this investigation.

1

2

3
This question is about Group 1 elements.

A sodium atom is represented as \( \frac{23}{11}\text{Na} \)

Complete Figure 6 to show the electronic structure of a sodium atom. \([1 \text{ mark}]\)

A teacher demonstrated the reaction between lithium and water.

The teacher repeated the demonstration using sodium and then potassium with water.

The teacher wore eye protection.

Suggest two other safety precautions the teacher should take. \([2 \text{ marks}]\)

1. 

2. 

Universal indicator is added to the solution formed in the reaction between potassium and water. The universal indicator becomes purple in colour.

Which ion causes universal indicator to turn purple?

Tick one box.

- $\text{H}^+$
- $\text{K}^+$
- $\text{OH}^-$
- $\text{O}^{2-}$

[1 mark]

Question 4 continues on the next page
Table 3 gives the diameter of atoms of Group 1 elements.

<table>
<thead>
<tr>
<th>Element</th>
<th>Diameter of atom in nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium</td>
<td>0.304</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.372</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.454</td>
</tr>
<tr>
<td>Rubidium</td>
<td>0.496</td>
</tr>
<tr>
<td>Caesium</td>
<td>0.530</td>
</tr>
</tbody>
</table>

Explain how the diameter of the atom affects the reactivity of Group 1 elements.  

[4 marks]
Two students investigated the electrolysis of copper sulfate solution.

When copper sulfate solution is electrolysed, copper is produced at the negative electrode.

What substance is produced at the positive electrode when copper sulfate solution is electrolysed?

Tick one box.

- Hydrogen
- Oxygen
- Sulfur
- Sulfur dioxide
The students varied and measured the current in the circuit.

Complete Figure 7 to show a circuit that could be used.

Use the correct circuit symbols.

[3 marks]

Figure 7

Question 5 continues on the next page
The students made the following hypothesis:

‘The mass of copper deposited on the negative electrode will be directly proportional to the current.’

Table 4 shows the students’ results.

<table>
<thead>
<tr>
<th>Current in amps</th>
<th>Mass of copper deposited on the negative electrode in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.12</td>
<td>0.024</td>
</tr>
<tr>
<td>0.24</td>
<td>0.047</td>
</tr>
<tr>
<td>0.36</td>
<td>0.057</td>
</tr>
<tr>
<td>0.48</td>
<td>0.095</td>
</tr>
<tr>
<td>0.60</td>
<td>0.118</td>
</tr>
<tr>
<td>0.72</td>
<td>0.142</td>
</tr>
</tbody>
</table>

Student A said that the results did support the hypothesis.

Student B said that the results did not support the hypothesis.

Explain the extent to which the data in Table 4 supports the students’ hypothesis.

[4 marks]
Calculate the number of moles of copper deposited on the negative electrode when the current is 0.72 A.

Give your answer in standard form.

Use Table 4.

Relative atomic mass \((A_r)\) of copper = 63.5

\[\text{Number of moles} = \text{__________}\]

What change to the investigation would increase the mass of copper deposited on the negative electrode?

Tick one box.

- Decrease the concentration of copper sulfate solution
- Decrease the volume of copper sulfate solution
- Increase the distance between the electrodes
- Increase the time the circuit is switched on for
When a conductor carrying a current is placed in a magnetic field a force is exerted on the conductor.

This is called the motor effect.

Describe how the direction of the force can be determined using Fleming’s Left Hand Rule.

[4 marks]
**Figure 8** shows apparatus to demonstrate the motor effect.

### Figure 8

The piece of wire is fixed so that it cannot move.

This is the method used.

1. Place the pair of magnets in their holder on the balance.
2. Set the reading on the balance to zero.
3. Pass a current through the wire.
4. Record the new reading on the balance.

When there is a current in the wire, the reading on the balance increases.

Explain in terms of forces why the reading increases.

[3 marks]

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
In one experiment, the teacher determined that the force on the wire was 2.14 mN.

The current in the wire was 0.32 A.

The length of wire within the magnetic field was 0.048 m.

Calculate the magnetic flux density between the two magnets.

Use the Physics Equations Sheet.

Give your answer to 2 significant figures.

\[
\text{Magnetic flux density} = \ \text{______ T}
\]
Astronauts have landed on the Moon on six separate occasions.

The Moon is in a circular orbit around the Earth. The speed of the Moon is constant.

Explain why the Moon is accelerating. [3 marks]

Question 7 continues on the next page
The astronauts moved around the surface of the Moon in a lunar rover. 

**Figure 9** shows a lunar rover.

![Figure 9](image)

At one point, the lunar rover accelerated from 1.4 m/s to 2.6 m/s

The acceleration of the lunar rover was 0.31 m/s²

Which calculation could be used to calculate the distance travelled $s$ during this acceleration?

**[1 mark]**

Tick one box.

\[
s = \sqrt{2.6^2 - 1.4^2 - 2 \times 0.31}
\]

\[
s = \frac{1.4^2 - 2.6^2}{2 \times 0.31}
\]

\[
s = \frac{2.6^2 - 1.4^2}{2 \times 0.31}
\]

\[
s = \frac{2 \times (2.6^2 - 1.4^2)}{0.31}
\]
The lunar rover used four electric motors connected in parallel to a 36 V battery.

The maximum output power of one motor was 190 W.

The efficiency of each motor was 72%.

Calculate the current drawn from the battery when all four motors were operating at maximum power.

Current = _____________ A

Question 7 continues on the next page
Scientists once thought that the Moon formed elsewhere in the solar system and later came to orbit the Earth.

Studies of Moon rocks brought back by the astronauts showed that the rocks were extremely similar to those found on Earth.

This led to a new theory about how the Moon formed called the ‘Giant Impact Hypothesis’.

According to the Giant Impact Hypothesis, a small planet collided with the Earth. Molten rock thrown up by the collision then formed the Moon.

Suggest why a new theory was developed.

[2 marks]
Crude oil is a mixture of hydrocarbons.
Hydrocarbons can be used as fuels.

One alkane hydrocarbon contains 34 hydrogen atoms.
What is the formula of the hydrocarbon? [1 mark]

Tick **one** box.

- C_{15}H_{34}
- C_{16}H_{34}
- C_{17}H_{34}
- C_{18}H_{34}

**Question 8 continues on the next page**
Figure 10 represents a fractionating column used to separate crude oil.

Figure 10

Describe how crude oil is separated using fractional distillation.

[4 marks]
Propane is a hydrocarbon fuel obtained from crude oil.

Figure 11 shows the displayed equation for the complete combustion of propane.

Table 5 shows bond energies.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond energy in kJ/mol</th>
</tr>
</thead>
<tbody>
<tr>
<td>C–C</td>
<td>347</td>
</tr>
<tr>
<td>C–H</td>
<td>413</td>
</tr>
<tr>
<td>O=O</td>
<td>495</td>
</tr>
<tr>
<td>C=O</td>
<td>799</td>
</tr>
<tr>
<td>O–H</td>
<td>467</td>
</tr>
</tbody>
</table>

Calculate the overall energy change in kJ/mol for the reaction.

Use Figure 11 and Table 5.

Overall energy change = ____________ kJ/mol
Some fuels are obtained from plants.

Evaluate the environmental impact of fuels obtained from plants and from crude oil.

[4 marks]
Butane is another hydrocarbon fuel obtained from crude oil.

The equation for the complete combustion of butane is:

$$2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$$

14.5 g of butane was burned in 72.0 g of oxygen.

Determine the limiting reactant.

You must include calculations in your answer.

Relative atomic masses ($A_r$): $C = 12, \ H = 1, \ O = 16$

END OF QUESTIONS