Please write clearly in block capitals.

Centre number ________________

Candidate number ________________

Surname ________________________

Forename(s) ________________________

Candidate signature ________________________

GCSE
ADDITIONAL SCIENCE
CHEMISTRY

Higher Tier  Unit Chemistry C2

Wednesday 14 June 2017  Morning  Time allowed: 1 hour

Materials
For this paper you must have:
• a ruler
• the Chemistry Data Sheet (enclosed).
You may use a calculator.

Instructions
• Use black ink or black ball-point pen.
• Fill in the boxes at the top of this page.
• Answer all questions.
• You must answer the 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.

Information
• The marks for questions are shown in brackets.
• The maximum mark for this paper is 60.
• You are expected to use a calculator where appropriate.
• You are reminded of the need for good English and clear presentation in your answers.
• Question 2 should be answered in continuous prose.
  In this question you will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Advice
• In all calculations, show clearly how you work out your answer.

For Examiner’s Use

Examiner’s Initials

<table>
<thead>
<tr>
<th>Question</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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<tr>
<td>4</td>
<td></td>
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<tr>
<td>5</td>
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<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
</tr>
</tbody>
</table>
There are no questions printed on this page
This question is about rates of reaction.

The equation for the decomposition of hydrogen peroxide is:

\[
2\text{H}_2\text{O}_2 (\text{aq}) \rightarrow 2\text{H}_2\text{O} (\text{l}) + \text{O}_2 (\text{g})
\]

**Figure 1** shows the apparatus a student used to investigate the rate of reaction for the decomposition of hydrogen peroxide.

**Question 1 continues on the next page**
The graph in Figure 2 shows the results.

**Figure 2**

<table>
<thead>
<tr>
<th>Volume of oxygen in cm³</th>
<th>Time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
</tr>
</tbody>
</table>

**1 (a) (i)** Draw a smooth curve of best fit on Figure 2.  
[1 mark]

**1 (a) (ii)** Give the volume of oxygen produced at 25 seconds.  
[1 mark]

Volume of oxygen = ______________ cm³

**1 (a) (iii)** After how many seconds does the reaction stop?  
[1 mark]

Time = ______________ seconds
1 (a) (iv) The student concluded that the rate of reaction decreases with time.

Explain how the results support this conclusion. [2 marks]
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1 (a) (v) Calculate the mean rate of reaction during the first 10 seconds. [1 mark]
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_____________________________________________________________________________________
Mean rate of reaction = _________________ cm³ per second

1 (b) The student investigated the effect of concentration on the rate of the reaction.
The student repeated the experiment with greater concentrations of hydrogen peroxide.

1 (b) (i) The catalyst was kept the same. Give two other control variables. [2 marks]
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Question 1 continues on the next page
1 (b) (ii) State and explain, in terms of particles and collisions, how a greater concentration affects the rate of the reaction.

[3 marks]

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1 (c) Describe how increasing the amount of catalyst affects the results in Figure 2.

[2 marks]

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13
In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Metals and thermosoftening polymers have different properties.

Figure 3 shows structures of a metal and a thermosoftening polymer.

Explain how the properties of a metal and a thermosoftening polymer relate to their structures.

In your answer you should describe the structures of a metal and a thermosoftening polymer.

[6 marks]
This question is about oxygen and substances containing oxygen.

(a) (i) Complete Figure 4 to show the arrangement of the outer shell electrons in an oxygen molecule.

Use dots (●) and crosses (×) to represent the electrons.

[2 marks]

(a) (ii) Name the type of bonding in an oxygen molecule.

[1 mark]

(a) (iii) Explain why oxygen has a low boiling point.

[2 marks]
3 (b) Magnesium oxide is produced when oxygen reacts with magnesium.

3 (b) (i) Balance the equation for the reaction. [1 mark]

$$\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$$

3 (b) (ii) Magnesium oxide contains magnesium ions (Mg$^{2+}$) and oxide ions (O$^{2-}$).

Describe what happens, in terms of electrons, when magnesium atoms react with oxygen atoms to produce magnesium oxide. [3 marks]

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3 (b) (iii) Magnesium oxide nanoparticles can be made.

What are nanoparticles? [1 mark]

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Question 3 continues on the next page
3 (c) **Figure 5** shows a furnace lined with silicon dioxide (SiO$_2$).

The temperature in the furnace is 1500 °C.

**Figure 5**

Explain, in terms of structure and bonding, why silicon dioxide is used to line furnaces. [3 marks]

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3
This question is about sulfuric acid (H₂SO₄) and ethene.

Sulfuric acid is used to produce copper sulfate (CuSO₄).

The equation for the reaction is:

\[
\text{CuO(s)} + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{CuSO}_4(\text{aq}) + \text{H}_2\text{O}(\text{l})
\]

4 (a) Describe a method for making copper sulfate crystals from copper oxide and sulfuric acid.

[4 marks]

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4 (b) Calculate the mass of copper oxide required to produce 24.95 g of copper sulfate crystals (CuSO₄·5H₂O).

Relative formula mass (\(M_r\)) of copper sulfate crystals = 249.5

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

[3 marks]

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Mass of copper oxide = ________________________ g
4 (c) Ethene and sulfuric acid are used to make many substances.

4 (c) (i) Table 1 shows data about wealth of countries, ethene production and sulfuric acid production.

<table>
<thead>
<tr>
<th>Country</th>
<th>Wealth of country in billions of dollars</th>
<th>Ethene production in kilotonnes</th>
<th>Sulfuric acid production in kilotonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4000</td>
<td>13 900</td>
<td>36 000</td>
</tr>
<tr>
<td>B</td>
<td>1300</td>
<td>4 400</td>
<td>6 600</td>
</tr>
<tr>
<td>C</td>
<td>1290</td>
<td>2 700</td>
<td>26 000</td>
</tr>
<tr>
<td>D</td>
<td>620</td>
<td>3 100</td>
<td>2 500</td>
</tr>
<tr>
<td>E</td>
<td>460</td>
<td>1 500</td>
<td>4 200</td>
</tr>
<tr>
<td>F</td>
<td>310</td>
<td>650</td>
<td>6 700</td>
</tr>
</tbody>
</table>

How does the wealth of countries relate to their production of ethene and sulfuric acid?

[2 marks]

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4 (c) (ii) Suggest why the use of ethene has increased in the last 50 years.

[1 mark]

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_____________________________________________________________________________________
5 This question is about methods of analysis.

5 (a) A student wanted to compare the colours in two inks, A and B, using paper chromatography.

5 (a) (i) Describe a method the student could use. [4 marks]

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5 (a) (ii) Figure 6 shows the student’s results.

Figure 6

<table>
<thead>
<tr>
<th>Ink A</th>
<th>Ink B</th>
</tr>
</thead>
<tbody>
<tr>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>•</td>
<td>•</td>
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</tr>
</tbody>
</table>

Compare the colours in the inks A and B. [2 marks]

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Do not write outside the box.
5 (b) A method of instrumental analysis is gas chromatography linked to mass spectrometry (GC-MS).

5 (b) (i) Describe how gas chromatography separates substances in a mixture of compounds. [3 marks]

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5 (b) (ii) A mass spectrometer is used to identify the substances.

What information about each substance is given by the mass spectrometer? [1 mark]

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Turn over for the next question
6 This question is about sodium chloride.

6 (a) A student reacted hydrochloric acid and sodium hydroxide solution to produce sodium chloride solution.

The student:
- measured 50 cm³ of hydrochloric acid into a glass beaker
- measured the initial temperature of the hydrochloric acid
- added 50 cm³ of sodium hydroxide solution
- stirred the mixture and measured the highest temperature of the solution.

6 (a) (i) The hydrochloric acid and sodium hydroxide solution were the same concentration.

Suggest one reason why the temperature change could be greater than expected. [1 mark]

Tick (✓) one box.

The volume of the sodium hydroxide solution was more than 50 cm³.

The volume of the hydrochloric acid was more than 50 cm³.

The initial temperature reading was too low.

The highest temperature reading was too low.

6 (a) (ii) The student did the investigation three times.

Table 2 shows the results.

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>Initial temperature of the acid in °C</th>
<th>Highest temperature of solution in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>32</td>
</tr>
</tbody>
</table>
What conclusion can you make about the reaction from the results in Table 2?

[1 mark]

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6 (b) The student electrolysed sodium chloride solution.

6 (b) (i) Explain what happens at the negative electrode and why sodium is not produced.

[3 marks]

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6 (b) (ii) Chlorine gas is produced at the positive electrode. Complete the half equation.

[1 mark]

_____ Cl$^-$ _________ + _________

6 (b) (iii) Explain why the pH of the solution after electrolysis was 14

[2 marks]

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END OF QUESTIONS