GCSE Chemistry
Foundation Tier  Unit Chemistry C3

Wednesday 15 June 2016  Afternoon  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 6 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.
Answer all questions in the spaces provided.

1 This question is about elements and the periodic table.

1 (a) Use the correct answers from the box to complete the sentences.

<table>
<thead>
<tr>
<th>atoms</th>
<th>atomic weights</th>
<th>electrons</th>
<th>proton numbers</th>
</tr>
</thead>
</table>

Newlands’ and Mendeleev’s periodic tables show the elements in order of their ________________________________ .

Following the discovery of protons and ________________________________, the modern periodic table shows the elements in order of their ________________________________ .

1 (b) Figure 1 shows the position of six elements in the modern periodic table.

**Figure 1**

<table>
<thead>
<tr>
<th>Li</th>
<th>K</th>
<th>Rb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>Fe</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 (b) (i) Which **one** of these six elements has the lowest boiling point?  

[1 mark]

______________________________

1 (b) (ii) Complete the sentence.

[1 mark]

In the periodic table, rubidium (Rb) is in Group ________.
1 (b) (iii) Which of these three elements is the most reactive?

Tick (✓) one box.  

- Lithium (Li)  
- Sodium (Na)  
- Potassium (K)

1 (b) (iv) Which two statements are correct?

Tick (✓) two boxes.  

- Iron has a higher density than potassium.  
- Iron is softer than potassium.  
- Iron reacts vigorously with water.  
- Iron forms ions that have different charges.

Question 1 continues on the next page.
1 (c) **Figure 2** shows sodium being put into water.

**Figure 2**

Sodium  Spatula

Water  Trough

Describe three observations that can be seen when sodium is put into water.  

[3 marks]

1. ____________________________________________________________________________

2. ____________________________________________________________________________

3. ____________________________________________________________________________
2 This question is about water.

2 (a) Hard water contains dissolved compounds.

2 (a) (i) Which ion causes water to be hard? [1 mark]

Tick (√) one box.

Ca\(^{2+}\)  
H\(^{+}\)  
Na\(^{+}\)  

2 (a) (ii) The table has three statements about hard water.

Tick (√) one advantage and tick (√) one disadvantage of using hard water. [2 marks]

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard water is good for the development of bones.</td>
<td></td>
</tr>
<tr>
<td>Hard water can be distilled to make pure water.</td>
<td></td>
</tr>
<tr>
<td>Hard water needs more soap to form lather.</td>
<td></td>
</tr>
</tbody>
</table>

2 (b) The two types of hard water are permanent hard water and temporary hard water.

2 (b) (i) What forms when permanent hard water reacts with soap? [1 mark]

Tick (√) one box.

drinking water  
scale  
scum
2 (b) (ii) What forms when temporary hard water is boiled?  
Tick (✓) one box. 
- distilled water 
- pure water 
- soft water 

2 (c) Water filters used in the home remove some dissolved compounds and improve the quality of the tap water. 

Draw one line from each substance in the water filter to the improvement it makes to tap water. 

Substance in the water filter | Improvement to tap water
--- | ---
carbon | improves taste
ion-exchange resin | adds fluoride
silver | reduces microbes
removes hardness
This question is about energy changes in chemical reactions.

3 (a) Complete the word equation for the combustion of hydrogen.

hydrogen + oxygen → 

[1 mark]

3 (b) Figure 3 shows a simple energy level diagram.

3 (b) (i) Which arrow, A, B or C, shows the activation energy? 
Tick (✓) one box.

A

B

C

[1 mark]

3 (b) (ii) What type of reaction is shown by the energy level diagram in Figure 3? 
Give a reason for your answer.

Type of reaction ____________________________________________

Reason ____________________________________________________

________________________________________________________________________
For a reaction, the value of $A$ is 1370 kJ and $C$ is 3230 kJ. Calculate the value of $B$.

\[ B = \text{_______________} \text{kJ} \]

[1 mark]

Question 3 continues on the next page
3 (c) Alcohols are used as fuels.

A group of students investigated the amount of energy released when different alcohols are burned. The students used the apparatus shown in Figure 4.

**Figure 4**

Beaker

50 g of water

Alcohol

3 (c) (i) Figure 5 shows the start temperature and the final temperature of the water.

**Figure 5**

<table>
<thead>
<tr>
<th>Start temperature</th>
<th>Final temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>°C</td>
</tr>
<tr>
<td>21</td>
<td>37</td>
</tr>
<tr>
<td>22</td>
<td>38</td>
</tr>
<tr>
<td>23</td>
<td>39</td>
</tr>
</tbody>
</table>

Write the start temperature and the final temperature of the water in Table 1. Work out the increase in temperature to complete Table 1.

[3 marks]

**Table 1**

<table>
<thead>
<tr>
<th>Start temperature of the water in °C</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Final temperature of the water in °C</td>
<td></td>
</tr>
<tr>
<td>Increase in temperature in °C</td>
<td></td>
</tr>
</tbody>
</table>
3 (c) (ii) The students worked out the heat energy released by burning 1 g of each alcohol. The students used the equation:

\[ \text{Heat energy released} = m \times 4.2 \times \text{increase in temperature} \]

Look at Figure 4. What is the value of \( m \)?

\[ m = \underline{\phantom{0000}} \text{ g} \]

3 (c) (iii) Table 2 shows the students’ results.

<table>
<thead>
<tr>
<th>Name of alcohol</th>
<th>Number of carbon atoms in one molecule of alcohol</th>
<th>Heat energy released when 1 g of alcohol is burned in kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>1</td>
<td>11.4</td>
</tr>
<tr>
<td>Ethanol</td>
<td>2</td>
<td>14.5</td>
</tr>
<tr>
<td>Propanol</td>
<td>3</td>
<td>20.1</td>
</tr>
<tr>
<td>Butanol</td>
<td>4</td>
<td>16.8</td>
</tr>
<tr>
<td>Pentanol</td>
<td>5</td>
<td>17.2</td>
</tr>
</tbody>
</table>

Which value of heat energy released is anomalous?

\[ \underline{\phantom{0000}} \]

3 (c) (iv) Look at Table 2.

What is the relationship between the number of carbon atoms in one molecule of alcohol and the heat energy released when 1 g of the alcohol is burned?

\[ \underline{\phantom{0000}} \]

Question 3 continues on the next page
3 (c) (v) The value in a data book for the amount of heat energy released when 1 g of butanol is burned completely is 36.2 kJ.

Suggest two reasons why the students' result for butanol is lower than the data book value. [2 marks]

1 ___________________________________________________________________________________

_____________________________________________________________________________________

2 ___________________________________________________________________________________

_____________________________________________________________________________________

3 (c) (vi) The displayed structure of butanol is:

\[
\begin{align*}
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} & \quad \text{C} & \quad \text{C} & \quad \text{O} & \quad \text{H} \\
\text{H} & \quad \text{H} & \quad \text{H} & \quad \text{H} 
\end{align*}
\]

What is the functional group of the alcohol? [1 mark]

Tick (✓) one box.

- C — C
- C — H
- O — H
This question is about the Haber process.

**Figure 6** shows a flow diagram for the Haber process.

**Figure 6**

Nitrogen gas  \(\rightarrow\)  Reactor containing iron  \(\rightarrow\)  Mixture of gases (nitrogen, hydrogen and ammonia)  \(\rightarrow\)  Separator  \(\rightarrow\)  Mixture of unreacted gases (nitrogen and hydrogen)  \(\rightarrow\)  Liquid ammonia

4 (a) (i) Nitrogen gas and hydrogen gas are obtained from different sources. Draw one line from each gas to its source.

[2 marks]

<table>
<thead>
<tr>
<th>Gas</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Air</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Iron ore</td>
</tr>
</tbody>
</table>

Question 4 continues on the next page
4 (a) (ii) Explain why iron is used in the reactor for the Haber process. [2 marks]

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________ 

4 (a) (iii) Describe how the ammonia is separated from the other gases. [2 marks]

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

4 (a) (iv) What happens to the mixture of unreacted gases (nitrogen and hydrogen)? [1 mark]

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________ 

4 (b) The reaction to produce ammonia is reversible. Complete the word equation for this reaction. [2 marks]

nitrogen + _______________
This question is about reactions of ethanoic acid and the analysis of salts.

Figure 7 shows the apparatus used to investigate the reaction of ethanoic acid with calcium carbonate.

5 (a) (i) Describe a change that would be seen in each test tube.
Give a reason for each change.

[4 marks]

Test tube 1

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Test tube 2

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Question 5 continues on the next page
5 (a) (ii) Complete the displayed structure of ethanoic acid. 

\[ \text{H} \quad \text{C} \quad \text{C} \quad \text{H} \]

[1 mark]

5 (a) (iii) Ethanoic acid is a carboxylic acid. Complete the sentence.

[2 marks]

Carboxylic acids react with alcohols in the presence of an ____________ catalyst to produce pleasant-smelling compounds called ____________.

5 (b) Figure 8 shows four test tubes containing three different salt solutions and water.

Figure 8

<table>
<thead>
<tr>
<th>Potassium chloride solution</th>
<th>Calcium nitrate solution</th>
<th>Ammonium sulfate solution</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each solution and the water was tested with:

- silver nitrate in the presence of dilute nitric acid
- barium chloride in the presence of dilute hydrochloric acid.
Complete the table of results.

<table>
<thead>
<tr>
<th></th>
<th>Potassium chloride solution</th>
<th>Calcium nitrate solution</th>
<th>Ammonium sulfate solution</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test with silver nitrate in the presence of dilute nitric acid</td>
<td>no change</td>
<td>no change</td>
<td></td>
<td>no change</td>
</tr>
<tr>
<td>Test with barium chloride in the presence of dilute hydrochloric acid</td>
<td>no change</td>
<td>white precipitate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5 (c) Flame tests can be used to identify metal ions.

5 (c) (i) Complete the following sentences.

The flame colour for potassium ions is _________________.

The flame colour for calcium ions is _________________.

5 (c) (ii) Give one reason why a flame test would not show the presence of both potassium ions and calcium ions in a mixture.

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

A student has to check if two samples of hydrochloric acid, A and B, are the same concentration.

Describe how the student could use the apparatus and the solutions in Figure 9 to carry out titrations.

[6 marks]