GCSE CHEMISTRY
Higher Tier  Unit Chemistry C3

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(c)(i) 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.
This question is about water.

1 (a) Rainwater is soft water.

How is hard water formed from rainwater?

[2 marks]

1 (b) A sample of hard water contains magnesium sulfate.

**Figure 1** shows the solubility of magnesium sulfate at different temperatures.
What conclusions can be made from Figure 1?

Use patterns and values from the graph in your answer. [3 marks]

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1 (c) Give one advantage and one disadvantage of hard water. [2 marks]

Advantage __________________________________________________________
________________________________________________________________________
Disadvantage __________________________________________________________
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1 (d) Describe and explain how hard water is softened using an ion exchange column. [3 marks]

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Turn over for the next question

10
There are no questions printed on this page
2 This question is about the combustion of alcohols.

2 (a) What is the structure of methanol?

Tick (✔️) one box.

- CH₃OH
- CH₃CH₂OH
- CH₃CH₂CH₂OH
- CH₃CH₂CH₂CH₂OH

2 (b) Figure 2 shows four energy level diagrams for the combustion of an alcohol. Which diagram, A, B, C, or D, shows an arrow for the overall energy change?

Tick (✔️) one box.

Figure 2

[Diagram with arrows indicating energy level changes]

Question 2 continues on the next page
2 (c) **Figure 3** shows apparatus used to measure the energy released when an alcohol is burned.

**Figure 3**

- Thermometer
- Glass beaker
- Water
- Alcohol burner

2 (c) (i) In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Describe how a student could use the apparatus in **Figure 3** to compare the energy released when methanol and ethanol are burned.

You should include any measurements the student would need to make.

Do not describe how to do any calculations.

Do not describe any improvements to the apparatus.

[6 marks]
2 (c) (ii) The student calculated the energy released by the alcohols. The calculated values were less than the values in a data book.

Explain how the apparatus in Figure 3 could be improved to obtain more accurate results.

[2 marks]
This question is about elements and compounds.

3 (a) In 1869 Mendeleev produced an early version of the periodic table.

Figure 4 shows part of Mendeleev's periodic table.

Figure 4

<table>
<thead>
<tr>
<th></th>
<th>H</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Li</td>
<td>Be</td>
<td>B</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>Na</td>
<td>Mg</td>
<td>Al</td>
<td>Si</td>
<td>P</td>
</tr>
<tr>
<td>K</td>
<td>Ca</td>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
</tr>
</tbody>
</table>

3 (a) (i) Why did Mendeleev leave gaps in his periodic table?

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3 (a) (ii) Give one reason why the elements Ti, V, Cr and Mn should not be where Mendeleev placed them.

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3 (b) Figure 5 shows an outline of the modern periodic table.

Figure 5

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>Na</td>
<td>Br</td>
</tr>
<tr>
<td>Li</td>
<td></td>
<td>Cl</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I</td>
</tr>
</tbody>
</table>

3 (b) (i) Why, in terms of electrons, is bromine in Group 7?

[1 mark]

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3 (b) (ii) Bromine reacts with sodium iodide.

The word equation for the reaction is:

\[ \text{bromine} \quad + \quad \text{sodium iodide} \quad \rightarrow \quad \text{sodium bromide} \quad + \quad \text{iodine} \]

This reaction shows that bromine is more reactive than iodine.

Explain why, in terms of electrons.

[3 marks]

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Question 3 continues on the next page
3 (c) Figure 6 shows test tubes containing solutions of sodium iodide, potassium bromide and iron(II) chloride.

![Figure 6](image)

3 (c) (i) A student tested each solution with silver nitrate in the presence of dilute nitric acid.

Write the result for sodium iodide solution in Table 1.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Sodium iodide solution</th>
<th>Potassium bromide solution</th>
<th>Iron(II) chloride solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result of adding silver nitrate</td>
<td>Cream precipitate</td>
<td>White precipitate</td>
<td></td>
</tr>
</tbody>
</table>

3 (c) (ii) The student tested new samples of each solution with sodium hydroxide solution.

Write the result for iron(II) chloride solution in Table 2.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>Sodium iodide solution</th>
<th>Potassium bromide solution</th>
<th>Iron(II) chloride solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Result of adding sodium hydroxide solution</td>
<td>No precipitate</td>
<td>No precipitate</td>
<td></td>
</tr>
</tbody>
</table>
3 (d) A flame test is done on a mixture of sodium iodide and potassium bromide.

Why would a flame test **not** show the presence of both sodium ions and potassium ions in the mixture?  

[1 mark]

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3 (e) Carboxylic acids are compounds containing carbon.

3 (e) (i) Complete **Figure 7** to show the displayed structure of ethanoic acid.  

[1 mark]

**Figure 7**

H

H — C — C

H

3 (e) (ii) Explain why ethanoic acid has a higher pH value than hydrochloric acid of the same concentration.  

[2 marks]

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Turn over for the next question
This question is about potassium and its compounds.

4 (a) (i) Potassium reacts with water to produce potassium hydroxide solution and a gas. 

Figure 8 shows the apparatus used for the reaction.

![Figure 8](image)

Figure 8

Complete and balance the equation for the reaction. 

\[ \boxed{\text{[2 marks]}} \]

\[ \boxed{\begin{array}{cc}
\_{ \text{K} } & \_{ \text{H}_2\text{O} } \\
\_ \text{KOH} & \_ \text{__________}
\end{array}} \]

4 (a) (ii) Potassium and lithium are in Group 1 of the periodic table.

Give two differences you would see between the reactions of potassium and lithium with water. 

\[ \boxed{\text{[2 marks]}} \]

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4 (b) Describe how a student could do titrations to find the mean volume of potassium hydroxide solution which would neutralise 25.00 cm$^3$ of nitric acid. [5 marks] 

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4 (c) The student found that 26.25 cm$^3$ of potassium hydroxide solution with a concentration of 0.20 moles per dm$^3$ neutralises 25.00 cm$^3$ of nitric acid.

The equation for the reaction is:

$$\text{KOH} + \text{HNO}_3 \rightarrow \text{KNO}_3 + \text{H}_2\text{O}$$

Calculate the concentration of the nitric acid. [3 marks]

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Concentration of nitric acid = ____________________ moles per dm$^3$
This question is about sulfuric acid and sulfates.

One reaction in the industrial production of sulfuric acid is:

$$2\text{SO}_2 (g) + \text{O}_2 (g) \rightleftharpoons 2\text{SO}_3 (g)$$

The forward reaction is exothermic.

5 (a) (i) Explain why a moderately high temperature, instead of a low temperature, is used for this reaction.

Use the information above and your knowledge.

[3 marks]

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5 (a) (ii) Explain why you would expect this reaction to be carried out at high pressure.

[2 marks]

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5 (a) (iii) This reaction is carried out at atmospheric pressure.

Suggest one advantage, other than cost, of using atmospheric pressure and not a high pressure for this reaction.

[1 mark]

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5 (b) Sulfuric acid is used to produce sulfates.

Describe how sodium hydroxide solution is used to distinguish between a solution of magnesium sulfate and a solution of aluminium sulfate.

[2 marks]

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Turn over the for the next question
6 This question is about ammonia and a compound produced from ammonia.

6 (a) Ammonia is produced by the Haber process.

6 (a) (i) The reactants in the Haber process are nitrogen and hydrogen.

Give the source of the hydrogen used for the Haber process. [1 mark]

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6 (a) (ii) The Haber process produces a mixture of the gases ammonia, hydrogen and nitrogen.

Table 3 shows boiling points for ammonia, hydrogen and nitrogen.

Table 3

<table>
<thead>
<tr>
<th></th>
<th>Boiling point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>–33</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>–260</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>–196</td>
</tr>
</tbody>
</table>

Explain how to separate ammonia from the mixture of gases.

Use the information in Table 3 to help you. [2 marks]

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Question 6 continues on the next page
6 (b) Ammonia is used to produce hydrazine (N₂H₄).

6 (b) (i) The equation for the decomposition of hydrazine is:

\[ \text{H} \begin{array}{c} \text{N} \end{array} \begin{array}{c} \text{N} \end{array} \begin{array}{c} \text{H} \end{array} \rightarrow \text{N} \equiv \text{N} + 2 \text{H} \rightarrow \text{H} \]

Bond energies are given in Table 4.

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond energy in kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>N ≡ N</td>
<td>941</td>
</tr>
<tr>
<td>N − H</td>
<td>391</td>
</tr>
<tr>
<td>N − N</td>
<td>160</td>
</tr>
<tr>
<td>H − H</td>
<td>432</td>
</tr>
</tbody>
</table>

Calculate the energy change for the decomposition of hydrazine. [3 marks]

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Energy change = _______________________ kJ
6 (b) (ii) The decomposition of hydrazine is exothermic.

Explain why, in terms of bond making and bond breaking. [2 marks]

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END OF QUESTIONS