C4
CHEMICAL CHANGES
TEST 3

GCSE
CHEMISTRY
AQA - COMBINED SCIENCE

Materials
For this paper you must have:
• Ruler
• Pencil, Rubber, Protractor and Compass
• Scientific calculator, which you are expected to use when appropriate

Instructions
• Answer all questions
• Answer questions in the space provided
• All working must be shown
• Do all rough work in this book. Cross out any rough work you don’t want to be marked

Information
• The marks for the questions are shown in brackets
A student investigated the electrolysis of sodium chloride solution. 

Figure 1 shows the apparatus used.

Figure 1

(a) Figure 1 shows the volume of gas B collected in 10 minutes.

What is the volume of gas B?

Volume of gas B = ____________________ cm\(^3\)  

(1)

(b) The table shows the student’s results using sodium chloride solution of concentration 30 g/dm\(^3\).

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Volume of gas B collected in 10 minutes in cm(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Calculate the mean volume of gas B collected in 10 minutes.

___________________________________________________________________
___________________________________________________________________

Mean volume = ____________________ cm\(^3\)  

(2)
The student repeated the experiment using different concentrations of sodium chloride solution. 

**Figure 2** shows some of the student’s results.

**Figure 2**

![Graph showing mean volume of gas B collected in 10 minutes in cm³ vs. concentration of sodium chloride solution in g/dm³]
(c) One point on **Figure 2** is anomalous.

What is the concentration and volume of the anomalous point?

Give a reason for your choice.

Concentration ____________________ g/dm³

Volume ____________________ cm³

Reason ____________________________________________________________

___________________________________________________________________

(d) Describe the trend shown on **Figure 2**.

___________________________________________________________________

___________________________________________________________________

(e) Draw one line from each type of variable to the description of the variable in the experiment.

<table>
<thead>
<tr>
<th>Type of variable</th>
<th>Description of variable in the experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent variable</strong></td>
<td>Concentration of sodium chloride solution</td>
</tr>
<tr>
<td><strong>Independent variable</strong></td>
<td>Power supply</td>
</tr>
<tr>
<td></td>
<td>Temperature of solution</td>
</tr>
<tr>
<td></td>
<td>Volume of gas collected</td>
</tr>
<tr>
<td></td>
<td>Volume of sodium chloride solution</td>
</tr>
</tbody>
</table>
Sodium chloride solution contains sodium ions \( \text{(Na}^+ \text{)} \) and chloride ions \( \text{(Cl}^- \text{)} \).

(f) Sodium chloride solution is electrolysed.

Explain why the sodium ions are attracted to the negative electrode.

___________________________________________________________________

___________________________________________________________________

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___________________________________________________________________

(2)

(g) Complete the sentence.

Choose the answer from the box.

<table>
<thead>
<tr>
<th>are too big</th>
<th>are too small</th>
<th>cannot move</th>
<th>have delocalised electrons</th>
</tr>
</thead>
</table>

Solid sodium chloride does **not** conduct electricity because

the ions _________________________________________.

(1)

(h) Which **two** gases are produced during the electrolysis of sodium chloride solution?

Tick **two** boxes.

- Carbon dioxide
- Carbon monoxide
- Chlorine
- Hydrogen
- Nitrogen

(2)

(Total 13 marks)
Humphrey Davy was a professor of chemistry.

In 1807 Humphrey Davy did an electrolysis experiment to produce potassium.

(a) (i) Humphrey Davy was the first person to produce potassium.

   Draw a ring around the correct answer to complete each sentence.

   Humphrey Davy’s experiment to produce this new element was quickly

   [ ] had a lot of money.
   [ ] had a lot of staff to help.
   [ ] was well qualified.

   [1]

   (ii) Other scientists were able to repeat Davy’s experiment.

   Draw a ring around the correct answer to complete each sentence.

   Being able to repeat Davy’s experiment is important because

   [ ] check the results of the experiment.
   [ ] see if the experiment is safe.
   [ ] take the credit for the discovery.

   [1]

(b) A student tried to electrolyse potassium chloride.

Potassium chloride contains potassium ions (K⁺) and chloride ions (Cl⁻).
(i) The student found that solid potassium chloride does not conduct electricity.
Use the correct answer from the box to complete the sentence.

| are too big | cannot move | have no charge |

Solid potassium chloride does not conduct electricity because
the ions ____________________________.

(ii) What could the student do to the potassium chloride to make it conduct electricity?

______________________________________________________________

(iii) During electrolysis why do potassium ions move to the negative electrode?

______________________________________________________________

(iv) Draw a ring around the correct answer to complete the sentence.

When the potassium ions reach the negative electrode

they turn into potassium ____________________________.

atoms. electrodes. molecules.

(Total 6 marks)

This question is about electrolysis.

(a) How many different elements are in the formula \( \text{AgNO}_3 \)?

Tick one box.

2 3 5 6

(1)

(b) How many atoms are in the formula \( \text{AgNO}_3 \)?

Tick one box.

2 3 5 6

(1)
An electric current is passed through silver nitrate solution.

**Figure 1** shows the apparatus.

The solution contains four ions:

- Ag⁺
- H⁺
- NO₃⁻
- OH⁻

(c) Where do the H⁺ and OH⁻ ions come from?

Tick **one** box.

- Air
- Electrodes
- Silver nitrate
- Water

(d) Ag⁺ ions and H⁺ ions are attracted to the negative electrode (cathode).

Give a reason why.

___________________________________________________________________
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(1)
(e) Silver is produced at the negative electrode (cathode) and not hydrogen.

What does this tell you about the reactivity of silver?

Tick one box.

- Silver is less reactive than hydrogen
- Silver is less reactive than oxygen
- Silver is more reactive than nitrate
- Silver is more reactive than water

(f) The hydroxide ion (OH\textsuperscript{−}) is attracted to the positive electrode (anode).

The equation shows what happens at the positive electrode (anode).

\[4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2 + 4\text{e}^-\]

Name the gas produced at the positive electrode (anode).

___________________________________________________________________

(1)
An electric current is passed through sodium chloride solution. **Figure 2** shows the apparatus.

**Figure 2**

After passing an electric current through sodium chloride solution one product is sodium hydroxide (NaOH) solution.

The presence of sodium hydroxide can be shown by adding an indicator.

Name an indicator.

Give the colour of the indicator in sodium hydroxide solution.

Indicator __________________________________________________________

Colour __________________________________________________________

(2)

(Total 8 marks)

This question is about metals and metal compounds.
(a) Copper oxide reacts with hydrochloric acid to produce copper chloride and water.

Copper oxide is insoluble in water.

Copper oxide is gradually added to hydrochloric acid until in excess.

Sketch a graph on Figure 1 to show how the pH of the hydrochloric acid would change.

**Figure 1**

![Graph showing pH change](image-url)
(b) Magnesium reacts with hydrochloric acid to produce magnesium chloride and hydrogen.

Plan an investigation to find the accurate volume of hydrogen produced from magnesium.

You do not need to write about safety precautions.
A student reacts different masses of copper oxide with excess zinc to produce copper.

Figure 2 shows the student’s results.

**Figure 2**

![Graph showing the relationship between mass of copper oxide reacted and mass of copper produced.]

(c) Calculate the gradient (slope) of the line on Figure 2.

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___________________________________________________________________
___________________________________________________________________
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Gradient = ____________________ g of copper per g of copper oxide

(2)
(d) Determine the mass of copper that can be produced from 75 g of copper oxide.

Use Figure 2

Mass = ____________________ g

(3)
(Total 14 marks)

When a metal carbonate reacts with an acid, a salt, carbon dioxide and water are produced.

(a) Describe how you would test for carbon dioxide gas.

Test _______________________________________________________________

Result _______________________________________________________________

(2)
(b) Describe how to make pure dry crystals of magnesium chloride from magnesium carbonate and a dilute acid.

In your method you should name the apparatus and reagents you plan to use.

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(6)
(Total 8 marks)
Two students investigated the electrolysis of copper sulfate solution.

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

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

Tick one box.

- Hydrogen
- Oxygen
- Sulfur
- Sulfur dioxide

(b) The students varied and measured the current in the circuit.

Complete the diagram below to show a circuit that could be used.
The students made the following hypothesis:

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

The table below 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>

(c) 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 the table above supports the students’ hypothesis.

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(4)
(d) 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 the table above.

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

Number of moles = ______________

(e) 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

(1)

(Total 11 marks)

A teacher demonstrated the extraction of copper from copper oxide.

This is the method used.

1. Mix 1.30 g of zinc and 1.59 g of copper oxide.
2. Heat the mixture strongly.
3. When the mixture starts to glow, stop heating.
4. Let the glow spread through the mixture.
5. Leave the mixture to cool.
6. Add hydrochloric acid to the cooled mixture.
7. Filter the mixture obtained in step 6.
(a) A student concluded that an exothermic reaction had taken place.

Explain how an observation made during the demonstration shows this.

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(2)

(b) The equation for the reaction between zinc and copper oxide is:

\[ \text{Zn} + \text{CuO} \rightarrow \text{ZnO} + \text{Cu} \]

1.59 g of copper oxide reacted.

Calculate the mass of copper produced.

Relative atomic masses (A_r): \( \text{Cu} = 63.5 \quad \text{O} = 16 \quad \text{Zn} = 65 \)

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\[ \text{Mass of copper produced} = \underline{\text{____________}} \text{ g} \]

(3)

(c) Explain why steps 6 and 7 result in only copper being obtained as the residue.

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(4)
(d) The ionic equation for the reaction is:

\[ \text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu} \]

Which statement about the reaction between zinc and copper ions is correct?

Tick **one** box.

- Copper ions have been oxidised because the copper ions have gained electrons.
- Copper ions have been oxidised because the copper ions have lost electrons.
- Zinc has been oxidised because the zinc atoms have gained electrons.
- Zinc has been oxidised because the zinc atoms have lost electrons.

(1)

(Total 10 marks)

Copper can be produced from copper(II) sulfate solution by two different methods.

**Method 1 – Electrolysis**

(a) To produce copper by electrolysis a student has inert electrodes, a d.c. power supply, a switch and electrical wires for the external circuit.

Draw and label the apparatus set up to produce copper from copper(II) sulfate solution by electrolysis.

(2)

(b) Suggest why the colour of the copper(II) sulfate solution fades during the electrolysis.

___________________________________________________________________
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(3)
(c) Explain how copper is produced from copper(II) sulfate solution by electrolysis.

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(4)

Method 2 – Displacement

(d) The chemical equation for the displacement of copper using iron is:

\[ \text{CuSO}_4 + \text{Fe} \rightarrow \text{Cu} + \text{FeSO}_4 \]

Calculate the minimum mass of iron needed to displace all of the copper from 50 cm\(^3\) of copper(II) sulfate solution.

The concentration of the copper(II) sulfate solution is 80 g CuSO\(_4\) per dm\(^3\).

Relative atomic masses \((A_r)\): O = 16; S = 32; Fe = 56; Cu = 63.5

Give your answer to 2 significant figures.

___________________________________________________________________
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___________________________________________________________________
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Mass of iron = ............................ g

(4)
(Total 13 marks)
The electrolysis of sodium chloride solution is an industrial process.

(a) Why do chloride ions move to the positive electrode?

-----------------------------------------------------------------------------

1

(b) Sodium chloride solution contains two types of positive ions, sodium ions (Na\(^+\)) and hydrogen ions (H\(^+\)).

Tick (✓) the reason why hydrogen is produced at the negative electrode and not sodium.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Tick (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen is a gas.</td>
<td></td>
</tr>
<tr>
<td>Hydrogen is less reactive than sodium.</td>
<td></td>
</tr>
<tr>
<td>Hydrogen is a non-metal.</td>
<td></td>
</tr>
<tr>
<td>Hydrogen ions travel faster than sodium ions.</td>
<td></td>
</tr>
</tbody>
</table>

1

(c) Solution X is alkaline.

Which ion makes solution X alkaline?

-----------------------------------------------------------------------------

1
(d) Electrolysis of sodium chloride solution produces hydrogen and chlorine. The hydrogen and chlorine can be used to make hydrogen chloride.

(i) The diagrams show how the outer electrons are arranged in atoms of hydrogen and chlorine.

[Diagram: H and Cl atoms with electrons]

Hydrogen atom  Chlorine atom

Complete the diagram to show how the electrons are arranged in a molecule of hydrogen chloride (HCl).

(ii) Name the type of bond between the hydrogen and the chlorine atoms in a molecule of hydrogen chloride.

________________________________________

(1)

(iii) Some hydrogen chloride was bubbled into water. This made a solution with a pH of 1.

Which ion gave the solution a pH of 1?

________________________________________

(1)

(Total 6 marks)
(a) Figure 1 shows the apparatus used to electrolyse silver nitrate (AgNO\(_3\)) solution.

Name the product discharged at each electrode.

Write a half equation for the reaction at each electrode.

Product at negative electrode (cathode) _____________________________________

Half equation for negative electrode
___________________________________________________________________

Product at positive electrode (anode) _____________________________________

Half equation for positive electrode
___________________________________________________________________

(4)
(b) **Figure 2** shows the apparatus used to electrolyse sodium chloride (NaCl) solution.

**Figure 2**

Hydrogen and chlorine are produced.

Explain how another different product is formed in solution during this electrolysis.

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___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
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(4)
(Total 8 marks)