C3
QUANTITATIVE CHEMISTRY
TEST 3

GCSE
CHEMISTRY
AQA - COMBINED SCIENCE

Mark Score (%)

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
Calamine lotion is used to treat itching. The main ingredients are two metal oxides.

(a) One of the metal oxides has a relative formula mass \((M_r)\) of 81.

The formula of this metal oxide is \(MO\).
(M is not the correct symbol for the metal.)

The relative atomic mass \((A_r)\) of oxygen is 16.

(i) Calculate the relative atomic mass \((A_r)\) of metal M.

\[
\frac{81}{A_r + 16} = 81.
\]

\[
A_r = \frac{81 \times 16}{81} = 16.
\]

Relative atomic mass \((A_r)\) = _____________

(ii) Use your answer to part (a)(i) and the periodic table on the Data Sheet to name metal M.

The name of metal M is ________________________________.
(b) The other metal oxide is iron(III) oxide.

This contains iron(III) ions (Fe$^{3+}$) and oxide ions (O$^{2-}$).

(i) Explain in terms of electrons how an iron atom (Fe) can change into an iron(III) ion (Fe$^{3+}$).

(ii) The diagram below represents the electronic structure of an oxygen atom (O).

Complete the diagram below to show the electronic structure of an oxide ion (O$^{2-}$).

This question is about methods of treating water.

(a) Chlorine is used to kill microorganisms in water. When chlorine is added to water a chemical reaction takes place. The equation for this reaction is shown below.

$$\text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{H}^+(\text{aq}) + \text{OCl}^-(\text{aq}) + \text{Cl}^-(\text{aq})$$

An acidic solution is produced when chlorine reacts with water.

Which ion, shown in the equation, makes the solution acidic? _________________

(Total 6 marks)
(b) Calcium hypochlorite tablets are added to water in some swimming pools to kill microorganisms.

The formula of calcium hypochlorite is \( \text{CaCl}_2\text{O}_2 \)

(i) Calculate the relative formula mass \( (M_r) \) of calcium hypochlorite.

Relative atomic masses: \( \text{O} = 16; \text{Cl} = 35.5; \text{Ca} = 40 \).

\[
\text{Relative formula mass (} M_r \text{) of calcium hypochlorite} = \text{__________________________} \\
\]

(ii) Calculate the percentage by mass of chlorine in calcium hypochlorite.

\[
\text{Percentage by mass of chlorine in calcium hypochlorite} = \text{__________________________} \% \\
\]

(iii) Calculate the mass of chlorine in a 20 g tablet of calcium hypochlorite.

\[
\text{Mass of chlorine} = \text{__________________________ g} \\
\]

(c) Waste water from some industrial processes sometimes contains harmful metal ions, such as chromium ions. These ions must be removed from the water before it can be returned to a river.

A method of removing chromium ions (\( \text{Cr}^{3+} \)) from water is represented by this equation.

\[
\text{Cr}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \rightarrow \text{Cr(OH)}_3(\text{s})
\]

(i) What type of substance would be added to the water to provide the \( \text{OH}^- \) ions?

\[
\text{__________________________} \\
\]

\[
\text{__________________________} \\
\]

\[
\text{__________________________} \\
\]

\[
\text{__________________________} \\
\]
Some students investigated magnesium oxide.

(a) Magnesium oxide has the formula MgO.

(i) Calculate the relative formula mass \((M_r)\) of magnesium oxide.

Relative atomic masses: O = 16; Mg = 24.

Relative formula mass = ___________________

(ii) Calculate the percentage by mass of magnesium in magnesium oxide.

Percentage by mass of magnesium in magnesium oxide = _______%

(iii) Calculate the mass of magnesium needed to make 25 g of magnesium oxide.

Mass of magnesium = ___________________ g
(b) The students calculated that if they used 0.12 g of magnesium they should make 0.20 g of magnesium oxide.

They did this experiment to find out if this was correct.

- The students weighed 0.12 g of magnesium ribbon into a crucible.
- They heated the magnesium ribbon.
- They lifted the lid of the crucible slightly from time to time to allow air into the crucible.
- The students tried to avoid lifting the lid too much in case some of the magnesium oxide escaped.
- When all of the magnesium appeared to have reacted, the students weighed the magnesium oxide produced.

The results of the experiment are shown below.

<table>
<thead>
<tr>
<th>Mass of magnesium used in grams</th>
<th>0.12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of magnesium oxide produced in grams</td>
<td>0.18</td>
</tr>
</tbody>
</table>

(i) The mass of magnesium oxide produced was lower than the students had calculated. They thought that this was caused by experimental error.

Suggest two experimental errors that the students had made.

________________________________________________________________________
________________________________________________________________________
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Give two reasons why they should have repeated the experiment.

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Follow the steps to find the percentage of iron in iron oxide.

Relative atomic masses: O 16; Fe 56.

(i) Step 1
Calculate the relative formula mass of iron oxide, Fe$_2$O$_3$.

___________________________________________________________________
___________________________________________________________________

(ii) Step 2
Calculate the total relative mass of just the iron atoms in the formula, Fe$_2$O$_3$.

___________________________________________________________________

(iii) Step 3
Calculate the percentage (%) of iron in the iron oxide, Fe$_2$O$_3$.

___________________________________________________________________

Percentage of iron _________________ %

(Total 3 marks)
Calcium carbonate tablets are used to treat people with calcium deficiency.

(a) Calculate the relative formula mass ($M_r$) of calcium carbonate.

Relative atomic masses: C = 12; O = 16; Ca = 40.

___________________________________________________________________
___________________________________________________________________

Relative formula mass = _______________

(2)

(b) Calculate the percentage of calcium in calcium carbonate, CaCO$_3$.

___________________________________________________________________
___________________________________________________________________

Percentage of calcium = _______________%

(2)

(c) Calculate the mass of calcium in each tablet.

___________________________________________________________________
___________________________________________________________________

Mass of calcium = _________________ g

(2)
(d) An unwanted side effect of this medicine is that it can cause the patient to have ‘wind’ (too much gas in the intestine).

The equation below represents the reaction between calcium carbonate and hydrochloric acid (the acid present in the stomach).

\[
\text{CaCO}_3 (s) + 2\text{HCl} (aq) \rightarrow \text{CaCl}_2 (aq) + \text{H}_2\text{O} (l) + \text{CO}_2 (g)
\]

Suggest why the patient may suffer from ‘wind’.

___________________________________________________________________
___________________________________________________________________

(1)
(Total 7 marks)

6 Iron ore contains iron oxide.

(i) Calculate the relative formula mass of iron oxide, \( \text{Fe}_2\text{O}_3 \).

Relative atomic masses: \( \text{O} = 16; \text{Fe} = 56 \).

___________________________________________________________________
___________________________________________________________________

Answer = __________________________

(2)

(ii) Calculate the percentage by mass of iron in iron oxide.

___________________________________________________________________

Percentage of iron = __________________________ %

(2)

(iii) Calculate the mass of iron that could be extracted from 1000 kg of iron oxide.

Use your answer to part (c) (ii) to help you with this calculation.

___________________________________________________________________

Mass of iron = __________________________ kg

(1)
(Total 5 marks)
Iron is an essential part of the human diet. Iron(II) sulfate is sometimes added to white bread flour to provide some of the iron in a person's diet.

(a) The formula of iron(II) sulfate is FeSO₄.

Calculate the relative formula mass (M_r) of FeSO₄

Relative atomic masses: O = 16; S = 32; Fe = 56.

The relative formula mass (M_r) =

(2)

(b) What is the mass of one mole of iron(II) sulfate? Remember to give the unit.

__________________________

(1)

(c) What mass of iron(II) sulfate would be needed to provide 28 grams of iron?

Remember to give the unit.

__________________________

(1)

(Total 4 marks)

8

(a) A chemist was asked to identify a nitrogen compound. The chemist carried out an experiment to find the relative formula mass (M_r) of the compound.

The M_r of the compound was 44.

Relative atomic masses: N = 14, O = 16

Draw a ring around the formula of the compound.

NO  NO₂  N₂O₄  N₂O
(b) Potassium nitrate is another nitrogen compound. It is used in fertilisers. It has the formula $\text{KNO}_3$.

The $M_r$ of potassium nitrate is 101.

Calculate the percentage of nitrogen by mass in potassium nitrate.

Relative atomic mass: $\text{N} = 14$.

___________________________________________________________________

___________________________________________________________________

Percentage of nitrogen = _______________ %

(2)

(Total 3 marks)

This question is about fluorine.

(a) Calcium reacts with fluorine to produce calcium fluoride ($\text{CaF}_2$).

Explain how oxidation and reduction have taken place in this reaction.

Write about electron transfer in your answer.

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(4)
(b) Explain why calcium fluoride has a high melting point.

___________________________________________________________________
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(c) Fluorine reacts with sulfur to produce sulfur hexafluoride (SF$_6$).

\[ \text{S} + 3\text{F}_2 \rightarrow \text{SF}_6 \]

Relative formula masses, $M_r$: $\text{F}_2 = 38$  $\text{SF}_6 = 146$

Calculate the mass of sulfur hexafluoride produced when 0.950 g of fluorine is reacted with an excess of sulfur.

Give your answer to 3 significant figures.

___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
___________________________________________________________________

Mass = ____________________ g

(5)
(Total 13 marks)
This cake recipe is taken from a cookery book.

**Soda Cake**

- Mix the flour and butter and add the sugar, currants and flavouring.
- Then add the beaten egg.
- Add a little milk with a teaspoonful of **baking soda (sodium hydrogencarbonate)** and mix it in well.
- Bake in a moderate oven for about 30 minutes.

When sodium hydrogencarbonate is heated in an oven, it forms carbon dioxide gas.

\[ 2 \text{NaHCO}_3 \xrightarrow{\text{Heat}} \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} + \text{CO}_2 \]

A teaspoonful of baking soda contains a mass of 11 g of sodium hydrogencarbonate. Calculate the mass of carbon dioxide that could be made from 11 g of sodium hydrogencarbonate. Show clearly how you work out your final answer.

Relative atomic masses: H = 1; C = 12; O = 16; Na = 23.

\[ \text{Mass of carbon dioxide} = \text{ } \text{g} \]

(Total 3 marks)