Surname ________________________________________________

Other Names ________________________________________________

Centre Number ________________________________________________

Candidate Number ________________________________________________

Candidate Signature ________________________________________________

GCSE CHEMISTRY

Higher Tier Paper 1

8462/1H

Thursday 17 May 2018 Morning

Time allowed: 1 hour 45 minutes

For this paper you must have:

• a ruler
• a scientific calculator
• the periodic table (enclosed).

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]
INSTRUCTIONS

• Use black ink or black ball-point pen.
• Answer ALL questions in the spaces provided.
• Do all rough work in this book. Cross through any work you do not want to be marked.
• In all calculations, show clearly how you work out your answer.

INFORMATION

• There are 100 marks available on this paper.
• The marks for questions are shown in brackets.
• You are expected to use a calculator where appropriate.
• You are reminded of the need for good English and clear presentation in your answers.

DO NOT TURN OVER UNTIL TOLD TO DO SO
Soluble salts are formed by reacting metal oxides with acids.

Give ONE other type of substance that can react with an acid to form a soluble salt. [1 mark]

Calcium nitrate contains the ions Ca$^{2+}$ and NO$_3^-$

Give the formula of calcium nitrate. [1 mark]
Describe a method to make pure, dry crystals of magnesium sulfate from a metal oxide and a dilute acid. [6 marks]
This question is about metals and metal compounds.

Iron pyrites is an ionic compound.

FIGURE 1 shows a structure for iron pyrites.

FIGURE 1

Determine the formula of iron pyrites.

Use FIGURE 1. [1 mark]
An atom of iron is represented as $^{56}_{26}\text{Fe}$

Give the number of protons, neutrons and electrons in this atom of iron. [3 marks]

Number of protons ______________________

Number of neutrons ______________________

Number of electrons ______________________

Iron is a transition metal.

Sodium is a Group 1 metal.

Give TWO differences between the properties of iron and sodium. [2 marks]

1 ______________________________________

_______________________________________

_______________________________________

2 ______________________________________

_______________________________________

_______________________________________

[Turn over]
Nickel is extracted from nickel oxide by reduction with carbon.

Explain why carbon can be used to extract nickel from nickel oxide. [2 marks]

[Answer space]

[Answer space]

[Answer space]

[Answer space]
An equation for the reaction is:

\[ \text{NiO} + \text{C} \rightarrow \text{Ni} + \text{CO} \]

Calculate the percentage atom economy for the reaction to produce nickel.

Relative atomic masses \((A_r)\): \(\text{C} = 12\) \(\text{Ni} = 59\)

Relative formula mass \((M_r)\): \(\text{NiO} = 75\)

Give your answer to 3 significant figures. [3 marks]

Percentage atom economy = \(\frac{\text{Actual mass of Ni}}{\text{Theoretical mass of Ni}} \times 100\) %
Chemical reactions can produce electricity.

FIGURE 2 shows a simple cell.

FIGURE 2
Which of these combinations would NOT give a zero reading on the voltmeter in FIGURE 2? [1 mark]

Tick ONE box.

<table>
<thead>
<tr>
<th>Electrode A</th>
<th>Electrode B</th>
<th>Electrolyte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Copper</td>
<td>Sodium chloride solution</td>
</tr>
<tr>
<td>Zinc</td>
<td>Zinc</td>
<td>Water</td>
</tr>
<tr>
<td>Copper</td>
<td>Zinc</td>
<td>Sodium chloride solution</td>
</tr>
<tr>
<td>Copper</td>
<td>Zinc</td>
<td>Water</td>
</tr>
</tbody>
</table>
Alkaline batteries are non-rechargeable.

03.2 Why do alkaline batteries eventually stop working? [1 mark]

03.3 Why can alkaline batteries NOT be recharged? [1 mark]
Hydrogen fuel cells and rechargeable lithium-ion batteries can be used to power electric cars.

Complete the balanced equation for the overall reaction in a hydrogen fuel cell. [2 marks]

\[ \underline{\text{H}_2} + \underline{\text{H}_2\text{O}} \]

[Turn over]
03.5 TABLE 1 shows data about different ways to power electric cars.

TABLE 1

<table>
<thead>
<tr>
<th></th>
<th>Hydrogen fuel cell</th>
<th>Rechargeable lithium-ion battery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time taken to refuel or recharge in minutes</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Distance travelled before refuelling or recharging in miles</td>
<td>Up to 415</td>
<td>Up to 240</td>
</tr>
<tr>
<td>Distance travelled per unit of energy in km</td>
<td>22</td>
<td>66</td>
</tr>
<tr>
<td>Cost of refuelling or recharging in £</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>Minimum cost of car in £</td>
<td>60 000</td>
<td>18 000</td>
</tr>
</tbody>
</table>
Evaluate the use of hydrogen fuel cells compared with rechargeable lithium-ion batteries to power electric cars.

Use TABLE 1 and your own knowledge.

[6 marks]
FIGURE 3 represents different models of the atom.

FIGURE 3
Which diagram shows the plum pudding model of the atom? [1 mark]

Tick ONE box.

A  B  C  D  E

Which diagram shows the model of the atom developed from the alpha particle scattering experiment? [1 mark]

Tick ONE box.

A  B  C  D  E

Which diagram shows the model of the atom resulting from Bohr’s work? [1 mark]

Tick ONE box.

A  B  C  D  E

[Turn over]
Define the mass number of an atom. [1 mark]
Element X has two isotopes. Their mass numbers are 69 and 71.

The percentage abundance of each isotope is:
- 60% of $^{69}\text{X}$
- 40% of $^{71}\text{X}$

Estimate the relative atomic mass of element X. [1 mark]

Tick ONE box.

- [ ] $< 69.5$
- [ ] Between 69.5 and 70.0
- [ ] Between 70.0 and 70.5
- [ ] $> 70.5$
Chadwick’s experimental work on the atom led to a better understanding of isotopes.

Explain how his work led to this understanding. [3 marks]
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

TABLE 2 shows the student’s results.

TABLE 2

<table>
<thead>
<tr>
<th>Metal</th>
<th>Temperature increase in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>0</td>
</tr>
<tr>
<td>Iron</td>
<td>13</td>
</tr>
<tr>
<td>Magnesium</td>
<td>43</td>
</tr>
<tr>
<td>Zinc</td>
<td>17</td>
</tr>
</tbody>
</table>
Plot the data from TABLE 2 on FIGURE 4 as a bar chart. [2 marks]

FIGURE 4

Temperature increase in °C

Metal
The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give ONE reason why this conclusion is NOT correct. [1 mark]

The temperature change depends on the reactivity of the metal.

The student’s results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results. [4 marks]
Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on FIGURE 5. [3 marks]
A student investigated the electrolysis of different substances.

FIGURE 6 shows the apparatus.

FIGURE 6

Explain why electrolysis would NOT take place in the apparatus shown in FIGURE 6. [2 marks]
Explain why graphite conducts electricity.

Answer in terms of the structure and bonding in graphite. [3 marks]
The student investigated how the volume of gases produced changes with time in the electrolysis of sodium chloride solution.

FIGURE 7 shows the apparatus.
The student made an error in selecting the apparatus for this investigation.

How should the apparatus be changed?

Give ONE reason for your answer. [2 marks]

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

[Turn over]
Another student used the correct apparatus.

This student measured the volumes of gases collected every minute for 20 minutes.

FIGURE 8 shows the student’s results.

FIGURE 8

Volume of gas collected in cm$^3$

<table>
<thead>
<tr>
<th>Time in minutes</th>
<th>Hydrogen</th>
<th>Chlorine</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>
Describe the trends shown in the results.

Use values from FIGURE 8. [3 marks]
The number of moles of each gas produced at the electrodes is the same.

No gas escapes from the apparatus.

Suggest ONE reason for the difference in volume of each gas collected. [1 mark]
Calculate the amount in moles of chlorine collected after 20 minutes.

Use FIGURE 8 on page 36.

The volume of one mole of any gas at room temperature and pressure is 24.0 dm$^3$

Give your answer in standard form. [3 marks]

Moles of chlorine = _________________ mol
This question is about Group 7 elements.

Chlorine is more reactive than iodine.

07.1 Name the products formed when chlorine solution reacts with potassium iodide solution. [1 mark]

07.2 Explain why chlorine is more reactive than iodine. [3 marks]
Chlorine reacts with hydrogen to form hydrogen chloride.

Explain why hydrogen chloride is a gas at room temperature.

Answer in terms of structure and bonding. [3 marks]
Bromine reacts with methane in sunlight.

FIGURE 9 shows the displayed formulae for the reaction of bromine with methane.

FIGURE 9

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

\[
\begin{align*}
\text{H} \quad \text{C} \quad \text{Br} & + \quad \text{H} \quad \text{Br}
\end{align*}
\]
TABLE 3 shows the bond energies and the overall energy change in the reaction.

**TABLE 3**

<table>
<thead>
<tr>
<th></th>
<th>C—H</th>
<th>Br—Br</th>
<th>C—Br</th>
<th>H—Br</th>
<th>Overall energy change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy in kJ/mol</td>
<td>412</td>
<td>193</td>
<td>X</td>
<td>366</td>
<td>-51</td>
</tr>
</tbody>
</table>
Calculate the bond energy $X$ for the $C\cdots Br$ bond.

Use FIGURE 9 on page 42 and TABLE 3 on page 43. [4 marks]

Bond energy $X = \underline{\phantom{00000}}$ kJ/mol
Titanium is a transition metal.

Titanium is extracted from titanium dioxide in a two stage industrial process.

STAGE 1 \[ \text{TiO}_2 + 2 \text{C} + 2 \text{Cl}_2 \rightarrow \text{TiCl}_4 + 2 \text{CO} \]

STAGE 2 \[ \text{TiCl}_4 + 4 \text{Na} \rightarrow \text{Ti} + 4 \text{NaCl} \]

Suggest ONE hazard associated with STAGE 1. [1 mark]

Water must be kept away from the reaction in STAGE 2.

Give ONE reason why it would be hazardous if water came into contact with sodium. [1 mark]
Suggest why the reaction in STAGE 2 is carried out in an atmosphere of argon and NOT in air. [2 marks]
Titanium chloride is a liquid at room temperature.

Explain why you would NOT expect titanium chloride to be a liquid at room temperature. [3 marks]

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________

____________________________________________________________________________________
In STAGE 2, sodium displaces titanium from titanium chloride.

Sodium atoms are oxidised to sodium ions in this reaction.

Why is this an oxidation reaction? [1 mark]

Complete the half equation for the oxidation reaction. [1 mark]

Na → ________ + __________
In STAGE 2, 40 kg of titanium chloride was added to 20 kg of sodium.

The equation for the reaction is:

\[ \text{TiCl}_4 + 4 \text{Na} \rightarrow \text{Ti} + 4 \text{NaCl} \]

Relative atomic masses (\(A_r\)):

Na = 23 \quad Cl = 35.5 \quad Ti = 48

Explain why titanium chloride is the limiting reactant.

You MUST show your working. [4 marks]
For a STAGE 2 reaction the percentage yield was 92.3%.

The theoretical maximum mass of titanium produced in this batch was 13.5 kg.

Calculate the actual mass of titanium produced. [2 marks]

Mass of titanium = ___________ kg

[Turn over]
This question is about acids and alkalis.

Dilute hydrochloric acid is a strong acid.

Explain why an acid can be described as both strong and dilute. [2 marks]

A 1.0 × 10⁻³ mol/dm³ solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0 × 10⁻⁵ mol/dm³ solution of hydrochloric acid? [1 mark]

pH = ________________________________
A student titrated 25.0 cm$^3$ portions of dilute sulfuric acid with a 0.105 mol/dm$^3$ sodium hydroxide solution.

TABLE 4 shows the student’s results.

**TABLE 4**

<table>
<thead>
<tr>
<th>Titration</th>
<th>Volume of sodium hydroxide solution in cm$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titration 1</td>
<td>23.50</td>
</tr>
<tr>
<td>Titration 2</td>
<td>21.10</td>
</tr>
<tr>
<td>Titration 3</td>
<td>22.10</td>
</tr>
<tr>
<td>Titration 4</td>
<td>22.15</td>
</tr>
<tr>
<td>Titration 5</td>
<td>22.15</td>
</tr>
</tbody>
</table>

The equation for the reaction is:

$$2 \text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{H}_2\text{O}$$

Calculate the concentration of the sulfuric acid in mol/dm$^3$

Use only the student’s concordant results.

Concordant results are those within 0.10 cm$^3$ of each other. [5 marks]
Concentration of sulfuric acid = 
___________________________ mol/dm³

[Turn over]
Explain why the student should use a pipette to measure the dilute sulfuric acid and a burette to measure the sodium hydroxide solution. [2 marks]
Calculate the mass of sodium hydroxide in 30.0 cm$^3$ of a 0.105 mol/dm$^3$ solution.

Relative formula mass ($M_r$): NaOH = 40

Mass of sodium hydroxide = _____________ g
There are no questions printed on this page

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