

Chemical Changes 4

Name: _____

Class: _____

Date: _____

Time: **74 minutes**

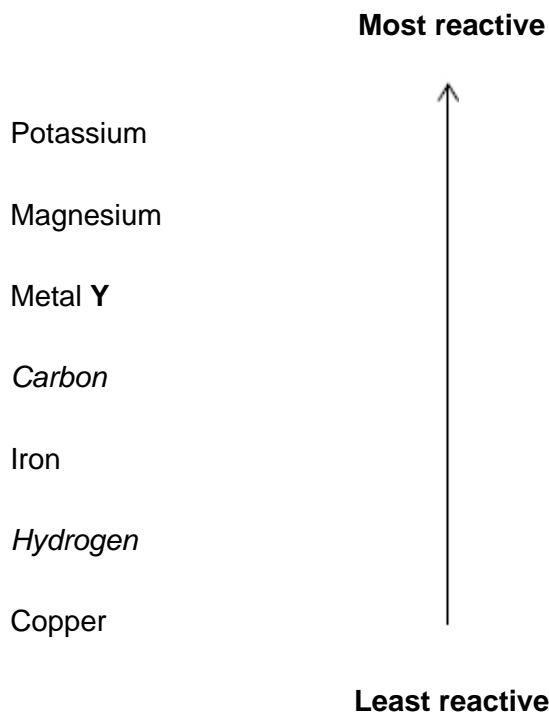
Marks: **68 marks**

Comments:

1.

This question is about elements and compounds.

(a) shows a reactivity series.



Give the method and conditions used to extract metal Y from a compound of metal Y.

(2)

Sodium reacts with titanium chloride (TiCl_4) to produce titanium.

(b) Complete the equation.

You should balance the equation.



(2)

(c) The reaction between sodium and titanium chloride is a redox reaction.

Write a half-equation to show that sodium is oxidised in this reaction.

(2)

(f) Explain how sodium chloride can conduct electricity.

(3)
(Total 17 marks)

2. This question is about electrolysis.

(a) Complete the sentence.

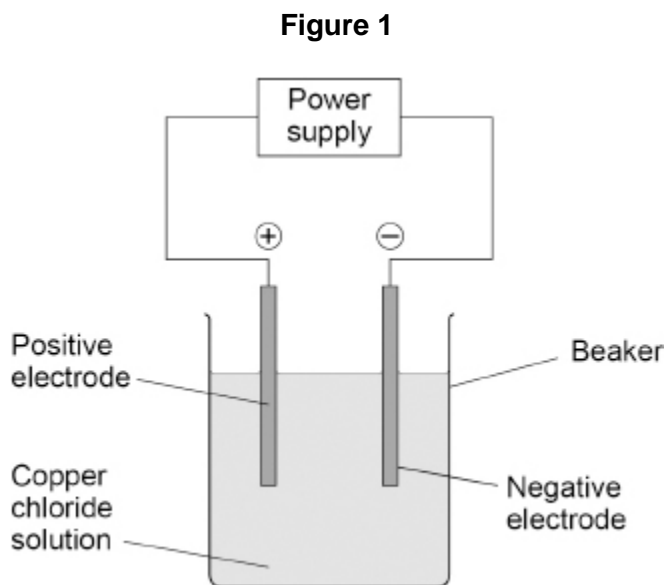
Choose the answer from the box.

gaseous	molten	solid
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Copper chloride can conduct electricity when in solution or
when _____.

(1)

Figure 1 shows the apparatus used for the electrolysis of copper chloride solution.



There are four ions in copper chloride solution:

- Cu^{2+}
- Cl^-
- H^+
- OH^-

(b) Why do Cl^- ions and OH^- ions move to the positive electrode?

(1)

(c) Where do the H^+ and OH^- ions come from in the electrolysis of copper chloride solution?

Tick (✓) **one** box.

Air

Copper chloride

Water

(1)

(d) Which ion produces a metal?

Tick (✓) **one** box.

Cu^{2+}

Cl^-

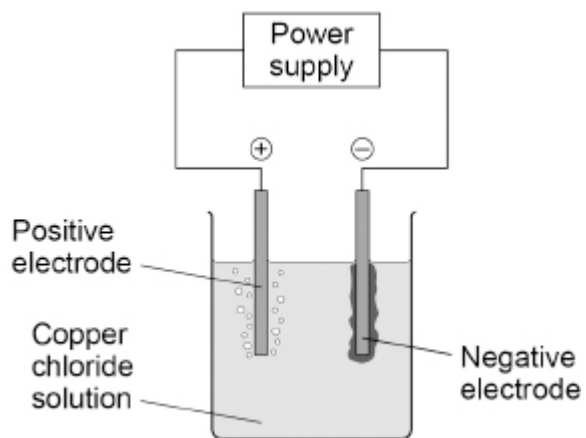
H^+

OH^-

(1)

(e) **Figure 2** shows the apparatus during the electrolysis of copper chloride solution.

Figure 2



Describe what is seen at each electrode during the electrolysis of copper chloride solution.

Positive electrode _____

Negative electrode _____

(2)

(f) 500 cm³ of copper chloride solution contains 6.50 g of copper chloride.

Calculate the mass of copper chloride in 40.0 cm³ of this copper chloride solution.

Mass = _____ g

(2)

(Total 8 marks)

3.

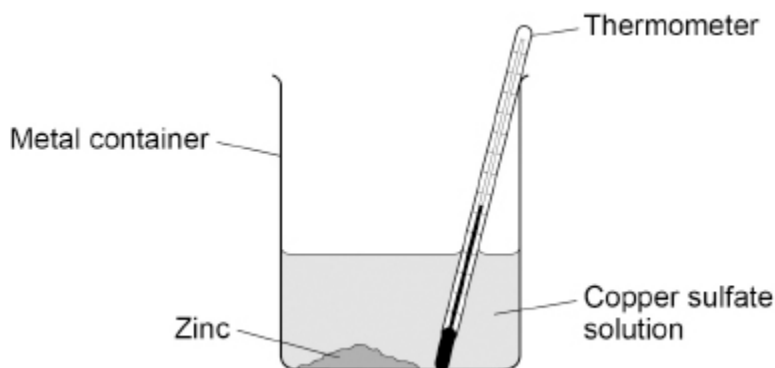
A student investigated the change in temperature when different masses of zinc were added to copper sulfate solution.

This is the method used.

1. Measure the volume of copper sulfate solution using a measuring cylinder.
2. Pour the copper sulfate solution into a metal container.
3. Add 2 g of zinc.
4. Measure the temperature of the solution.
5. Repeat steps 1 to 4 with different masses of zinc.

Figure 1 shows the apparatus.

Figure 1



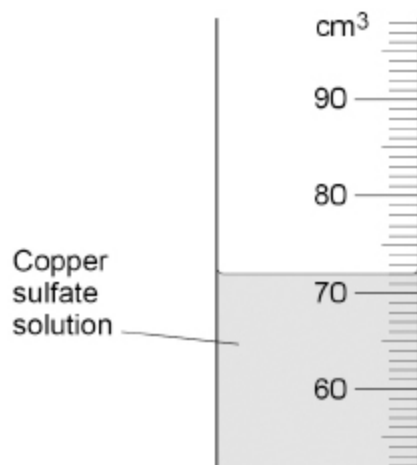
(a) Give **three** improvements to the investigation to make the results more accurate.

- 1 _____
- _____
- 2 _____
- _____
- 3 _____
- _____

(3)

(b) **Figure 2** shows part of the measuring cylinder.

Figure 2



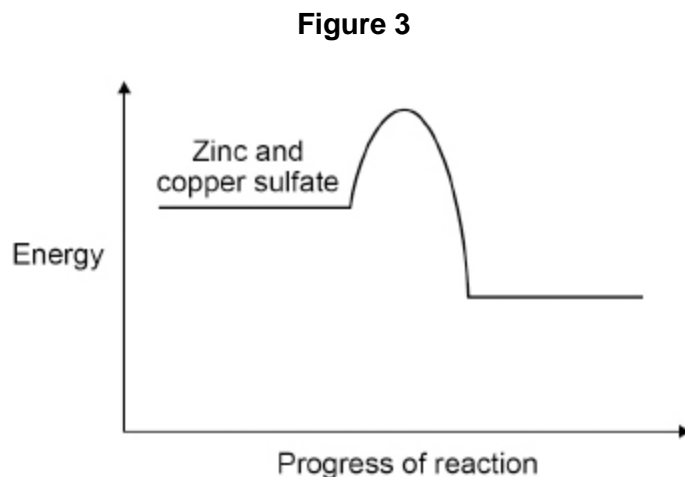
What is the volume of copper sulfate solution in **Figure 2**?

Volume = _____ cm³

(1)

(c) When zinc was added to copper sulfate solution the temperature increased.

Figure 3 shows the reaction profile.



What type of reaction is shown in **Figure 3**?

Tick (✓) **one** box.

Endothermic

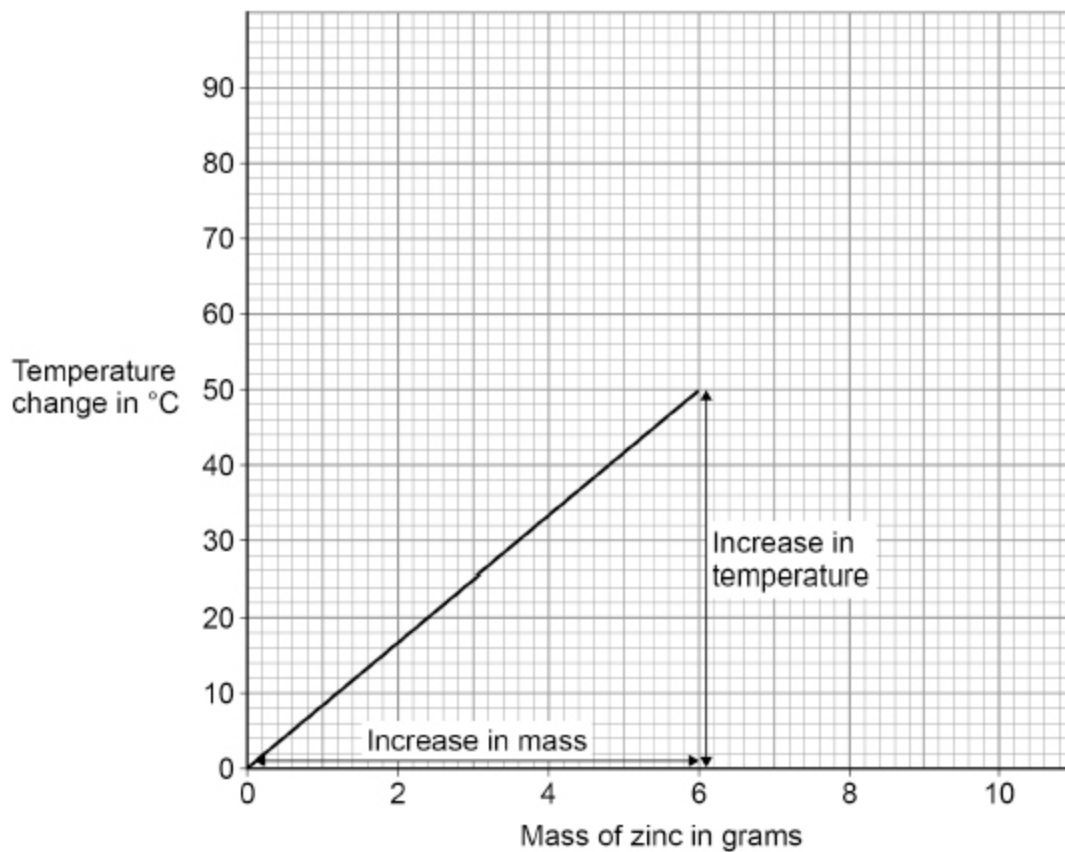
Exothermic

Neutralisation

(1)

Figure 4 shows the results.

Figure 4



(d) Determine the gradient of the line in **Figure 4**.

Use the equation:

$$\text{gradient} = \frac{\text{increase in temperature in } ^\circ\text{C}}{\text{increase in mass in grams}}$$

Gradient = _____ °C per g

(4)

- (e) Suggest why the student should **not** use more than 10 g of zinc.

Use **Figure 4**.

You should extend the graph line.

(2)

(Total 11 marks)

4.

Acids react to produce salts.

Universal indicator is added to water and then nitric acid is added to the mixture.

- (a) Give the colour change when nitric acid is added to the mixture of universal indicator and water.

Tick (✓) **one** box.

Blue to red

Green to purple

Green to red

Red to purple

(1)

(b) What happens to the pH of water when nitric acid is added?

Tick (✓) **one** box.

Decreases

Stays the same

Increases

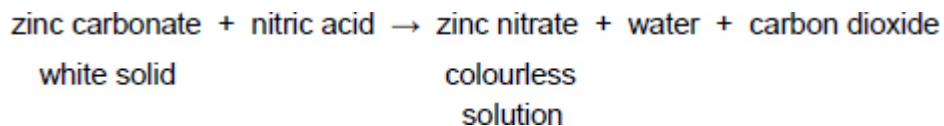
(1)

(c) What is the state symbol for nitric acid?

(1)

Zinc carbonate reacts with nitric acid.

The word equation for the reaction is:



(d) Give **two** observations that would be made when zinc carbonate is added to nitric acid until the zinc carbonate is in excess.

1 _____

2 _____

(2)

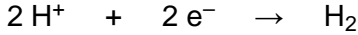
5.

This question is about the electrolysis of aqueous solutions.

Hydrogen gas and chlorine gas are produced when sodium chloride solution is electrolysed.

(a) Hydrogen ions (H⁺) are attracted to the negative electrode.

The half equation for the reaction at the negative electrode is:



What type of reaction happens at the negative electrode?

Give the reason for your answer.

Type of reaction _____

Reason _____

(2)

(b) Chloride ions are attracted to the positive electrode.

Complete the half equation for the production of chlorine gas (Cl₂).



(2)

(c) Hydrogen gas and oxygen gas are produced when sodium sulfate solution is electrolysed.

Explain how oxygen gas is produced in the electrolysis of sodium sulfate solution.

(4)

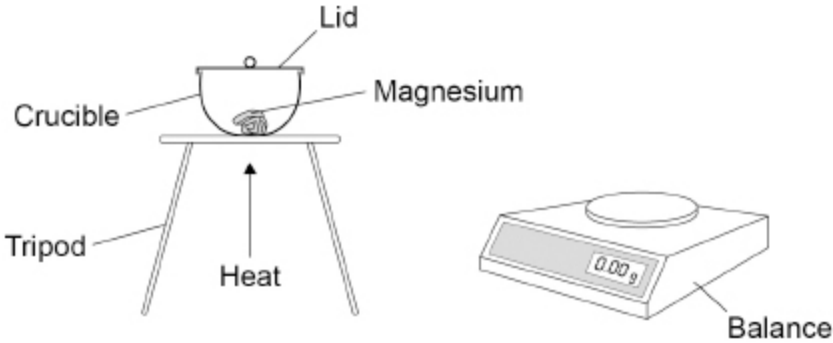
(Total 8 marks)

6.

Metal oxides are produced when metals are heated in air.

A student investigated the change in mass when 0.12 g of magnesium was heated in air.

The figure below shows the apparatus.



The student measured the mass of magnesium oxide produced.

(a) 0.12 g of magnesium reacted to produce 0.20 g of magnesium oxide.

Calculate the number of moles of oxygen gas (O₂) that reacted.

Relative atomic mass (A_r): O = 16

Moles of oxygen gas = _____

(3)

(b) The student repeated the experiment **without** a lid on the crucible.

Suggest why the mass of magnesium oxide produced would be different without a lid on the crucible.

(2)

(c) Copper reacts with oxygen to produce copper oxide.

63.5 g of copper produces 79.5 g of copper oxide.

Calculate the mass of copper oxide produced when 0.50 g of copper reacts with oxygen.

Give your answer to 3 significant figures.

Mass (3 significant figures) = _____ g

(3)

(d) Iron reacts with oxygen to produce an oxide of iron.

0.015 moles of iron reacts with 0.010 moles of oxygen gas (O₂).

Determine:

- the formula of the iron oxide produced
- the balanced symbol equation for the reaction.

Formula of iron oxide = _____

Balanced symbol equation

(4)

(Total 12 marks)

Mark schemes

1.

(a) electrolysis

1

of molten compound (of metal **Y**)

allow liquid for molten

1

OR

displacement (1)

by heating with a more reactive metal

or

by heating with potassium / magnesium (1)

(b) $4 \text{Na} + \text{TiCl}_4 \rightarrow 4 \text{NaCl} + \text{Ti}$

allow multiples

*allow 1 mark for NaCl **and** Ti with incorrect / no balancing*

2

(c) $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$

allow multiples

allow 1 mark for $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$ with incorrect balancing

2

ignore state symbols

(d) **method 1:**

$$\text{(moles of Al} = \frac{108}{27} \text{ =) } 4$$

1

$$\text{(moles CuCl}_2 = \frac{1210}{134.5} \text{ =)}$$

8.996

allow 9

1

(identifying limiting reagent)

4 moles Al gives 6 moles Cu

8.996 moles CuCl₂ gives

8.996 moles Cu

allow correct use of an incorrectly calculated value(s) for moles of Al and / or CuCl₂

1

therefore aluminium is the limiting reagent

must follow on from MP3

1

$$\text{(mass of Cu} = 2 \times 3 \times 63.5)$$

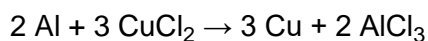
$$= 6 \times 63.5$$

1

$$= 381 \text{ (g)}$$

1

method 2:



$$(2 \times 27) \quad (3 \times 134.5) \quad (3 \times 63.5)$$

$$54 \text{ (g)} \quad 403.5 \text{ (g)} \quad 190.5 \text{ (g)}$$

$$(1) \quad (1) \quad (1)$$

(so)

108 g Al (reacts with 807 g CuCl₂) to produce 381 g Cu (1)

allow correct use of an incorrect calculation of mass for Al / CuCl₂ / Cu

(so) there is excess CuCl₂

or

807 g CuCl₂ is less than 1210 g CuCl₂(1)

therefore aluminium is limiting reactant (1)

must follow on from MP4 / MP5

method 3:

134.5 g CuCl₂ produces 63.5 g Cu (1)

(mass conversion 1.21 kg CuCl₂ =) 1210 (g) (1)

1210 g CuCl₂ produces ($\frac{63.5}{134.5} \times 1210 =$) 571 g Cu (1)

allow correct use of an incorrect / no conversion of mass of CuCl₂

54 g Al produces 190.5 g Cu (1)

108 g Al produces ($\frac{190.5}{54} \times 108 =$) 381 (g) (1)

(therefore) aluminium is the limiting reactant (1)

must follow on from MP3 and MP5

(e) delocalised electrons

allow free electrons

1

carry (electrical) charge through the metal / sodium

ignore throughout for through

ignore current / electricity

MP2 is dependent upon MP1

1

(f) (conducts electricity) when liquid / molten

or

(conducts electricity) in (aqueous) solution

allow (conducts electricity) when dissolved in water

1

(because) ions

1

(ions) are free to move

or

(ions) allow charge to flow

1

[17]

2.

(a) molten

1

(b) opposite (charges) attract

or

(the ions) are negative(ly charged)

1

(c) water

1

(d) Cu²⁺

1

(e) (positive electrode) bubbles / effervescence / fizzing
allow gas (is produced)

1

(negative electrode)
(pink / orange / red / brown) solid
allow copper (plating)
allow metal for solid

1

(f) $\frac{40.0}{500} \times 6.50$

1

= 0.52 (g)

1

[8]

3.

(a) any **three** from:

- use a (glass) beaker
or
use a polystyrene cup
- insulate the metal container
- add a lid
- measure copper sulfate solution with a pipette
- use same volume (of copper sulfate solution)
- use a more accurate balance
- stir (the mixture)
- record the initial **and** the highest temperature
- use a digital thermometer
or
use a more accurate thermometer
- repeat the experiment **and** calculate the mean (ignoring anomalous results)

3

(b) 72 (cm³)

1

(c) exothermic

1

(d) (increase in temperature =) 50 (°C) 1

increase in mass = 6 (g)

allow a value in the range 5.8 – 6 (g)

1

$$(\text{gradient} =) \frac{50}{6}$$

allow correct use of incorrectly determined value(s) for temperature and/or mass

1

$$= 8.33 \text{ (°C per g)}$$

1

(e) extends line on graph to 10 g of zinc 1

any **one** from:

- temperature (change) of 84 (°C)

allow a temperature (change) over 80 (°C)

- (so the solution will be) too hot
- (so the solution will be) over 100 (°C)
- (so the solution will) boil

1

[11]

4.

(a) green to red 1

(b) decreases 1

(c) (aq)

allow aq

ignore aqueous

ignore HNO₃

1

(d) any **two** from:

- (white) solid disappears
- fizzing **or** bubbles (of gas) **or** effervescence
allow a gas is produced

- (then) stops fizzing

- (white) solid left at the end / bottom

ignore colourless solution

2

(e) $\text{Zn}(\text{NO}_3)_2$	1
(f) Level 3: The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6
Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4
Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2
No relevant content	0

Indicative Content:

- react hydrochloric acid
- (with) copper oxide
- in a suitable container
- warm (hydrochloric) acid
- add copper oxide
- until is in excess
or
until solid remains
- stir
- filter excess copper oxide
- pour solution / filtrate into evaporating basin
- use of water bath
or
use of electric heater
- to heat gently
or
partially evaporate
- leave to cool / crystallise

For level 3 the correct chemicals must have been selected.

[12]

- 5.** (a) reduction
ignore electrolysis 1
- (as H⁺ ions) gain electrons 1
- (b) $2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-$
allow 2 Cl⁻ - 2 e⁻ → Cl₂
ignore state symbols
allow 1 mark for Cl₂ + e⁻
*allow 1 mark for - e⁻ (on lhs) **and** Cl₂ (on rhs)* 2
- (c) water molecules 1
- break down to produce OH⁻ ions
allow dissociate to produce OH⁻ ions 1
- (which are) attracted to the positive electrode 1
- (where OH⁻ ions are) oxidised
or
(where OH⁻ ions) lose electrons
ignore discharged
ignore oxygen is produced as no halide is present 1
- [8]**
- 6.** (a) (mass of oxygen = 0.20 - 0.12) = 0.08 (g) 1
- (moles of oxygen) = $\frac{0.08}{32}$ 1
- = 0.0025
allow 1 mark for 0.005
if derived from $\frac{0.08}{16}$ 1
- (b) (without a lid the) mass of magnesium oxide was less 1
- (because) products escaped allow magnesium oxide escaped 1

(c) (mass of copper oxide =)

$$\frac{79.5}{63.5} \times 0.5$$

1

$$= 0.62598 \text{ (g)}$$

1

$$= 0.626 \text{ (g)}$$

allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question

1

(d) 3:2 ratio Fe : O₂ (molecules)

or

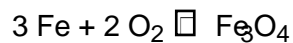
3:4 ratio Fe : O (atoms)

1

(formula) Fe₃O₄

allow 1 mark for Fe₃O₂ from 3:2 ratio Fe : O (atoms) (MP2 but not MP1)

1



allow multiples

allow correct use of incorrectly determined formula

allow 1 mark for Fe, O₂ and Fe₃O₄

or

allow 1 mark for Fe, O₂ and incorrectly determined formula

2

[12]