Chemical Changes 5

Name: _____

Class: _____

Date: _____

Time: **69 minutes**

Marks: **65 marks**

Comments:

1. A student investigated the temperature change when metal **X** was added to copper sulfate solution.

This is the method used.

1. Add 25 cm^3 of copper sulfate solution to a beaker.
2. Measure the temperature of the copper sulfate solution.
3. Add 1.0 g of metal **X** and stir.
4. Measure the highest temperature reached when metal **X** is added to copper sulfate solution.
5. Repeat steps 1 to 4 with different metals.

Figure 1 shows the apparatus used.

Figure 1

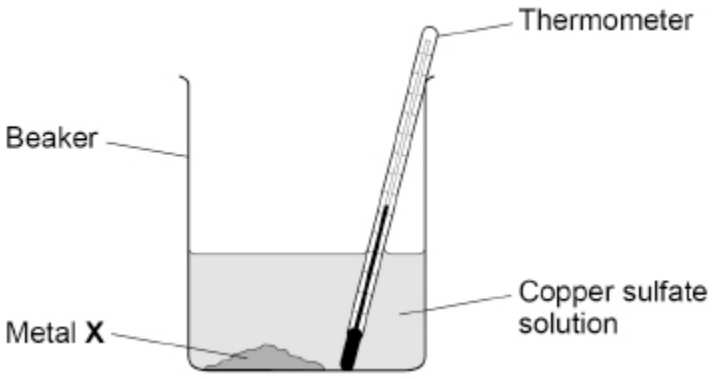
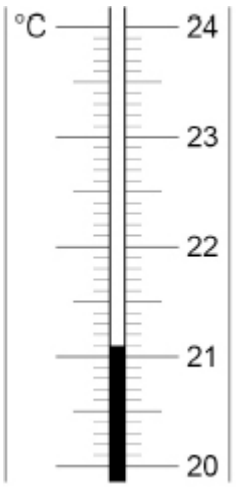


Figure 2 shows the thermometer reading of the copper sulfate solution at the start of the investigation.

Figure 2



(a) The highest temperature reached when metal **X** was added to copper sulfate solution was 35.5 °C

Determine the temperature change when metal **X** is added to copper sulfate solution.

Use **Figure 2**.

Highest temperature = 35.5 °C

Temperature at start = _____ °C

Temperature change = _____ °C

(2)

(b) Give **two** variables the student should keep the same in this investigation.

1. _____

_____

2. _____

_____

(2)

(c) The student repeated the experiment with metal **Y**.

Table 1 shows four results for metal **Y**.

Table 1

	Test 1	**Test 2**	**Test 3**	**Test 4**
Temperature change in °C	9.2	7.3	9.5	9.2

Calculate the mean temperature change for metal **Y**.

Do **not** include the anomalous result in your calculation.

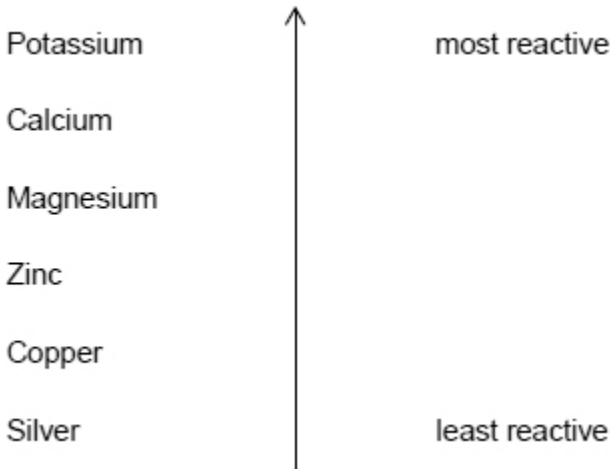
Mean temperature change = _____ °C

(2)

The more reactive the metal added to copper sulfate solution, the greater the temperature change.

Figure 3 shows a reactivity series.

Figure 3



(d) The student repeated the experiment.

The student added:

- magnesium to copper sulfate solution
- an unknown metal **A** to copper sulfate solution.

Table 2 shows the results.

Table 2

Metal	**Temperature change in °C**
Magnesium	12
Metal **A**	8

The student concludes metal **A** is zinc.

Give **one** reason why the student is correct.

Use **Figure 3** and **Table 2**.

_____

_____

(1)

(e) The student did the experiment with silver and copper sulfate solution.

What happens to the temperature of the mixture?

Use **Figure 3**.

Tick (✓) **one** box.

Decreases ☐

Increases ☐

Stays the same ☐

(1)

(f) Suggest **one** reason why the student should **not** add potassium metal to copper sulfate solution.

_____

_____

(1)

(g) 100 cm^3 of the copper sulfate solution contains 1.8 g of copper sulfate.

Calculate the mass of copper sulfate in 25 cm^3 of this copper sulfate solution.

_____

_____

_____

_____

Mass = _____ g

(2)

(Total 11 marks)

2. This question is about acids, alkalis and bases.

A student reacted zinc oxide powder with hydrochloric acid to produce zinc chloride solution.

(a) Complete the equation for the reaction by writing the state symbols.

$$ZnO(\_\_\_\_\_) + 2\ HCl(\_\_\_\_\_) \rightarrow ZnCl_2(\_\_\_\_\_) + H_2O(\_\_\_\_\_)$$

(2)

(b) Give **one** way that the student could speed up the reaction between zinc oxide powder and hydrochloric acid.

_____

_____

(1)

Hydrochloric acid was the limiting reactant.

(c) How could the student know when all the hydrochloric acid has reacted?

_____

_____

(1)

(d) How could the student obtain zinc chloride solution from the reaction mixture when all the hydrochloric acid has reacted?

_____

_____

(1)

(e) Describe how zinc chloride crystals are produced from zinc chloride solution.

_____

_____

_____

_____

(2)

Sulfuric acid and sodium hydroxide react to produce sodium sulfate.

(f) Sulfuric acid is gradually added to sodium hydroxide solution.

The pH of the mixture changes as the sulfuric acid is added until in excess.

Suggest the pH at:

- the start before sulfuric acid is added
- the end when sulfuric acid is in excess.

pH at start = _____

pH at end = _____

(2)

(g) Complete the symbol equation for the preparation of sodium sulfate.

You should balance the equation.

$$\_\_\_NaOH + H_2SO_4 \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$

(2)

(h) A solution of hydrochloric acid had a hydrogen ion concentration of 1.0 mol/dm^3

Water was added to the hydrochloric acid until the pH increased by 1

What was the hydrogen ion concentration of the hydrochloric acid after water had been added?

Tick (✓) **one** box.

100 mol/dm^3 ☐

10 mol/dm^3 ☐

0.10 mol/dm^3 ☐

0.010 mol/dm^3 ☐

(1)

(Total 12 marks)

3. This question is about salts and electrolysis.

A student wants to make copper chloride crystals.

The student adds excess copper oxide to some hot acid.

The student stirs the mixture.

(a) Which acid should the student use?

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

(1)

(b) Suggest how the student would know that excess copper oxide has been added.

_____

_____

(1)

(c) There are four more stages, **A**, **B**, **C** and **D**, to make copper chloride crystals.

The stages **A**, **B**, **C** and **D** are not in the correct order.

Stage **A**	Partially evaporate by heating with a water bath
Stage **B**	Filter the mixture into an evaporating basin
Stage **C**	Leave to crystallise
Stage **D**	Remove and dry the crystals

Put stages **A**, **B**, **C** and **D** in the correct order.

First stage _____

Second stage _____

Third stage _____

Fourth stage _____

(2)

(d) Molten copper chloride can be electrolysed.

State the product at each electrode when molten copper chloride is electrolysed.

Negative electrode _____

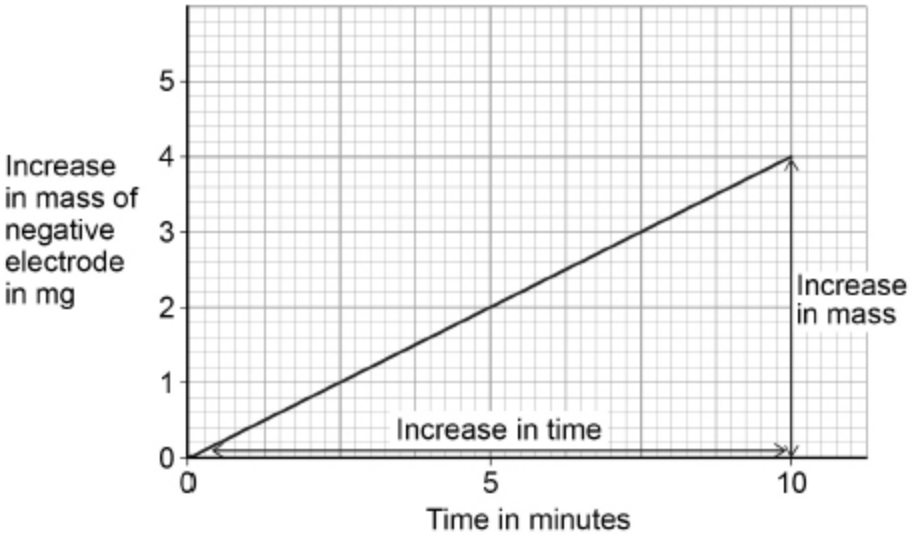
Positive electrode _____

(2)

(e) A solution of copper chloride is electrolysed.

The graph below shows the increase in mass of the negative electrode.

This increase is shown over a time of 10 minutes.



Calculate the gradient of the line in the graph.

Use the equation:

$$\text{Gradient} = \frac{\text{increase in mass in mg}}{\text{increase in time in minutes}}$$

Increase in mass _____

_____

Increase in time _____

_____

Gradient _____

_____

_____

_____

Gradient = _____ mg per minute

(3)

(f) Aluminium is produced by electrolysis of a molten mixture.

Complete the sentence.

Choose the answers from the box.

carbon	chloride	cryolite	oxide	sulfate	water

The molten mixture contains _____ and

aluminium _____ .

(2)

(Total 11 marks)

4. This question is about salts.

Ammonium nitrate solution is produced when ammonia gas reacts with nitric acid.

(a) Give the state symbol for ammonium nitrate solution.

_____

(1)

(b) What is the formula of nitric acid?

Tick (✓) **one** box.

HCl ☐

HNO_3 ☐

H_2SO_4 ☐

NH_4OH ☐

(1)

(c) Ammonia gas dissolves in water to produce ammonia solution.

Ammonia solution contains hydroxide ions, OH^-

A student adds universal indicator to solutions of nitric acid and ammonia.

What colour is observed in each solution?

Colour in nitric acid _____

Colour in ammonia solution _____

(2)

(d) The student gradually added nitric acid to ammonia solution.

Which row, **A**, **B**, **C** or **D**, shows the change in pH as the nitric acid is added until in excess?

Tick (✓) **one** box.

	pH of ammonia solution at start	**pH after addition of excess nitric acid**	
A	10	7	☐
B	2	10	☐
C	7	1	☐
D	10	2	☐

(1)

(e) Calculate the percentage by mass of oxygen in ammonium nitrate (NH_4NO_3).

Relative atomic masses (A_r): H = 1 N = 14 O = 16

Relative formula mass (M_r): NH_4NO_3 = 80

Percentage by mass of oxygen = _____ %

(3)

(f) Describe a method to investigate how the temperature changes when different masses of ammonium nitrate are dissolved in water.

You do **not** need to write about safety precautions.

(6)

(Total 14 marks)

5. This question is about acids and bases.

(a) Which ion is found in all acids?

Tick **one** box.

Cl^- ☐ H^+ ☐ Na^+ ☐ OH^- ☐

(1)

(b) Zinc nitrate can be produced by reacting an acid and a metal oxide.

Name the acid and the metal oxide used to produce zinc nitrate.

Acid _____

Metal oxide _____

(2)

(c) In an equation, zinc nitrate is written as $Zn(NO_3)_2(aq)$.

What does (aq) mean?

Tick **one** box.

Dissolved in water ☐

Insoluble ☐

Not all reacted ☐

Reactant ☐

(1)

(d) The pH of a solution is 8

Some hydrochloric acid is added to the solution.

Suggest the pH of the solution after mixing.

pH = _____

(1)

(e) **Table 1** shows the solubility of three solids in water at room temperature.

Table 1

Solid	**The mass of the solid that dissolves in 100 cm^3 of water**
Phosphorus oxide	50 g
Silicon dioxide	0 g
Sodium hydroxide	100 g

A teacher labelled these three solids **A**, **B** and **C**.

She gave a student the information shown in **Table 2**

Table 2

Solid	**Observation when added to water**	**pH of the solid in water**
A	colourless solution	14
B	colourless solution	2
C	solid does not dissolve	7

Describe a method that could be used to identify each of the three solids **A**, **B** and **C**.

You must use an indicator in the method.

Use information in **Table 1** and **Table 2**

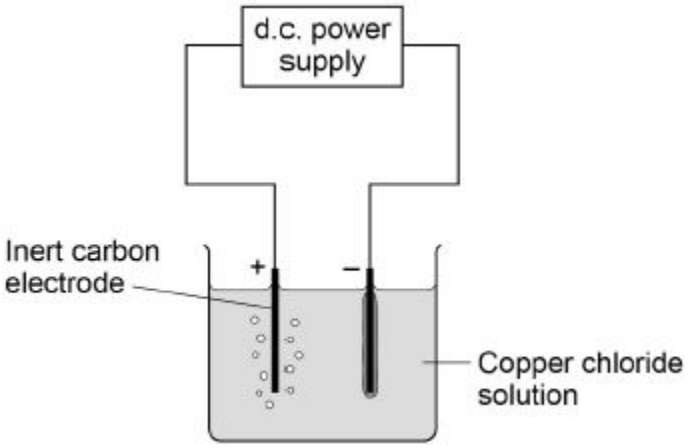
(4)

(Total 9 marks)

6. This question is about electrolysis.

A student investigates the mass of copper produced during electrolysis of copper chloride solution.

The diagram below shows the apparatus.



(a) Which gas is produced at the positive electrode (anode)?

Tick **one** box.

carbon dioxide ☐

chlorine ☐

hydrogen ☐

oxygen ☐

(1)

(b) Copper is produced at the negative electrode (cathode).

What does this tell you about the reactivity of copper?

Tick **one** box.

Copper is less reactive than hydrogen ☐

Copper is less reactive than oxygen ☐

Copper is more reactive than carbon ☐

Copper is more reactive than chlorine ☐

(1)

The table below shows the student's results.

	Total mass of copper produced in mg			
Time in mins	**Experiment 1**	**Experiment 2**	**Experiment 3**	**Mean**
1	0.60	0.58	0.62	0.60
2	1.17	1.22	1.21	1.20
4	2.40	2.41	2.39	2.40
5	3.02	**X**	3.01	3.06

(c) Determine the **mean** mass of copper produced after 3 minutes.

_____

_____

Mass = _____ mg

(1)

(d) Calculate the mass **X** of copper produced in **Experiment 2** after 5 minutes.

Use the table above.

Mass **X** = _____ mg

(2)

(e) The copper chloride solution used in the investigation contained 300 grams per dm^3 of solid $CuCl_2$ dissolved in 1 dm^3 of water.

The students used 50 cm^3 of copper chloride solution in each experiment.

Calculate the mass of solid copper chloride used in each experiment.

Mass = _____ g

(3)

(Total 8 marks)

1. (a) 21.1 (°C)

1

14.4 (°C)

allow correct use of an incorrect start temperature

1

(b) any **two** from:

- surface area of metal
- 25 cm^3 / volume of copper sulfate solution
- concentration of copper sulfate solution
- mass / 1 g of metal

ignore amount
ignore temperature
ignore stirring

2

(c) $\frac{9.2 + 9.5 + 9.2}{3}$ or $\frac{27.9}{3}$

1

= 9.3 (°C)

*if no other mark awarded allow **1** mark for 8.8 (°C)*

1

(d) (metal **A** / zinc) is less reactive (than magnesium)
or
(metal **A** / zinc) is lower in reactivity series
or
change in temperature is lower (with metal **A** / zinc)

allow converse

1

(e) stays the same

1

(f) too dangerous
or
too reactive

allow potassium would react with water

1

(g) $\frac{25}{100} \times 1.8$ **or** $\frac{1}{4} \times 1.8$

1

= 0.45 (g)

1

[11]

2.

(a) ZnO (**s**) + HCl (**aq**) → $ZnCl_2$ (**aq**) + H_2O (**l**)

*allow **1** mark for 2/3 correct state symbols*

2

(b) any **one** from:

- warm / heat the mixture
- increase the concentration of the (hydrochloric) acid

ignore add a catalyst

ignore stir

ignore powder

ignore add more zinc oxide

*do **not** accept volume / amount of (hydrochloric) acid*

*do **not** accept increase the surface area*

1

(c) zinc oxide remains

or

solid remains

ignore colour

allow zinc oxide is added until in excess

1

(d) filtration / filter

1

(e) heat

*do **not** accept heat to dryness*

1

leave to crystallise / cool

allow leave to evaporate some water

1

(f) (at start) value in range 12–14

must be in this order

1

(at end) value in range 0–3

1

(g) $2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$

*allow 1 mark for Na_2SO_4 **and** H_2O*

2

(h) $0.10\ mol/dm^3$

1

[12]

3.

(a) hydrochloric acid

1

(b) (black) solid remains (after stirring)

allow copper oxide remains

allow no more copper oxide reacts

1

(c)

first stage	**B**
second stage	**A**
third stage	**C**
fourth stage	**D**

*all 4 correct for **2** marks*

*allow **1** mark if either first stage or fourth stage is correct*

2

(d) (negative electrode) copper

allow Cu

1

allow Cl_2 / Cl

*do **not** accept chloride or Cl^-*

1

*if no other mark awarded allow **1** mark if elements are reversed*

(e) a reading of an increase in mass

correct linked reading of the increase in time

e.g. 4 (mg) in 10 (mins) scores 2 marks

1

1

correct evaluation of gradient

e.g. ($\frac{4}{10}$ =) 0.4 (mg per min)

allow correct calculation of gradient from incorrectly determined values for mass and/or time

1

(f) cryolite

this order only

1

oxide

1

[11]

4. (a) (aq)

allow aq

ignore aqueous

ignore formulae

1

(b) HNO_3

1

(c) red

allow orange or yellow

*do **not** accept green*

1

purple
or
blue

allow shades of purple e.g. violet

1

(d) D

(e) 3 × 16 **or** 48

1

$\frac{48}{80}$ (×100)

1

60 (%)

1

*an answer of 60 (%) scores **3** marks*

*an answer of 20 (%) scores **2** marks for:*

$\frac{16}{80}$ *(× 100) (1)*

= 20 (%) (1)

(f) **Level 3:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The design/plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

Level 1: The design/plan 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

Steps

- use a suitable container e.g. test tube
- use insulation
- add water
- measure the initial water temperature (with a thermometer)
- add stated mass e.g. 1g **or** 1 spatula
- stir (to dissolve the solid)
- measure the final (allow lowest or highest) temperature of the solution
- calculate the temperature difference **or** determine graphically
- repeat with different masses
- repeat with the same volume of water

to access level 3 there must be an indication of how the temperature change is determined using different masses dissolved in the same quantity of water

[14]

5. (a) H^+

1

(b) nitric (acid) **or** HNO_3

1

zinc (oxide) or ZnO

1

this order only

(c) dissolved in water

1

(d) any value from 0 to less than 8

1

(e) **Level 2:** The method would lead to the production of a valid outcome. Key steps are identified and 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

- add universal indicator **or** wide range indicator

indicator turns blue / purple / violet (because pH = 14)
or has highest pH or is an alkali
so A is sodium hydroxide

indicator turns red (because pH = 2)
or has lowest pH **or** is an acid
so B is phosphorus oxide

indicator turns green (because pH = 7)
or neutral
so C is silicon dioxide

- add solid to water

A and B dissolve; C does not
so C is silicon dioxide

[9]

6. (a) chlorine

1

(b) copper is less reactive than hydrogen

1

(c) 1.8 (mg)

allow an answer in range 1.7−1.9

1

(d) $\frac{3.02 + 3.01 + x}{3} = 3.06$

allow any other suitable method

1

3.15 (mg)

*if no other mark awarded allow 9.18 for **1** mark*

1

*an answer of 3.15 (mg) scores **2** marks*

(e) $\frac{50}{1000}$ **or** $\frac{1}{20}$ **or** 0.05

1

(0.05) × 300

the second mark is dependent on the first mark being scored

1

15 (g)

1

or

$\frac{300}{1000}$ **or** $\frac{3}{10}$ **or** 0.03 (1)

(0.3) × 50 (1)

the second mark is dependent on the first mark being scored

15 (g) (1)

if no other mark awarded allow 150 ***or*** *15 000 for* ***1*** *mark*

[8]