C5 Chemical Changes Homework task 1

Q1. A student investigated the reactivity of metals with hydrochloric acid. This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a polystyrene cup.
2. Measure the temperature of the hydrochloric acid.
3. Add one spatula of metal powder to the hydrochloric acid and stir.
4. Measure the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1 to 5 three more times.
7. Repeat steps 1 to 6 with different metals.

The table below shows the student's results.

Metal	**Temperature increase in °C**				**Mean temperature increase in °C**
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	
Cobalt	6	7	5	9	7
Magnesium	54	50	37	55	**X**
Zinc	18	16	18	20	18

(a) Calculate the mean temperature increase **X** for magnesium in the table above. Do **not** include the anomalous result in your calculation.

_____

_____

_____

_____

X = _____ °C

(2)

(b) Determine the order of reactivity for the metals cobalt, magnesium and zinc. Use the table above.

Most reactive _____

_____

Least reactive _____

(1)

(c) The range of measurements either side of the mean shows the uncertainty in the mean temperature increase. Complete the sentence. Use the table above.

The mean temperature increase for zinc is 18 ± _____°C

(1)

(d) What type of variable is the volume of hydrochloric acid in this investigation? Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

(1)

(e) Suggest **one** way of improving **step 3** in the method to give results which are more repeatable.

_____

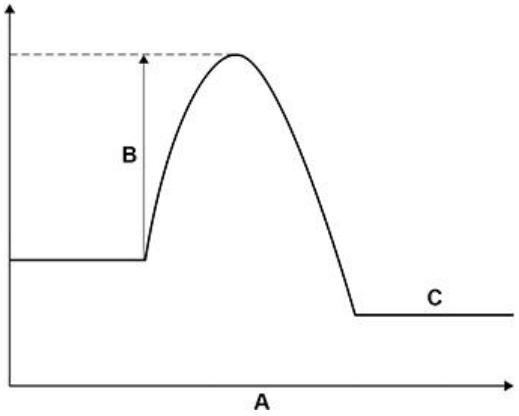
_____

_____

_____

(1)

(f) The figure below shows a reaction profile for the reaction of magnesium with hydrochloric acid.



What do labels **A**, **B** and **C** represent on the figure above? Choose answers from the box.

activation energy	**energy**	**overall energy change**
products	**progress of reaction**	**reactants**

A _____

B _____

C _____

(3)

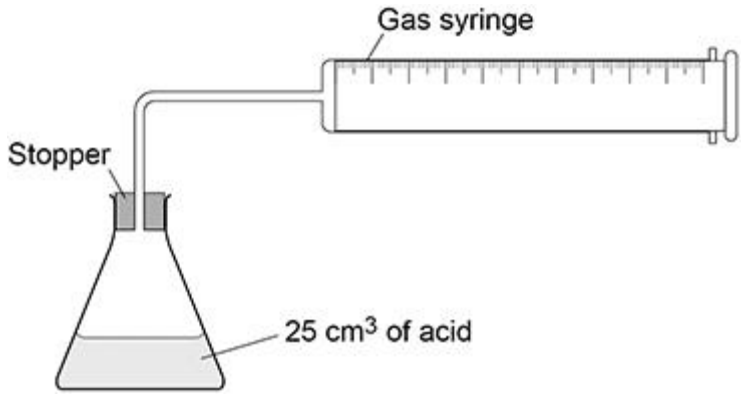
(Total 9 marks)

Q2. This question is about metal carbonates.

A student investigated the reaction of copper carbonate with an acid.

Figure 1 shows the apparatus.

Figure 1

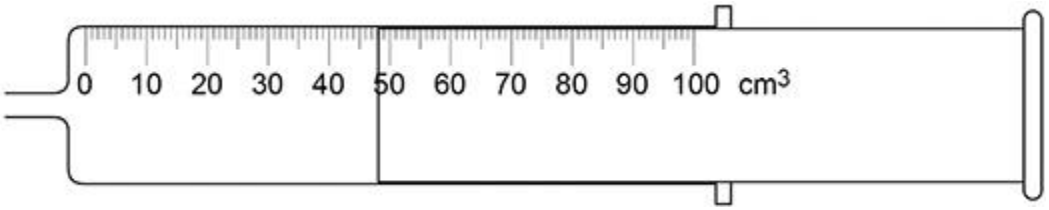


This is the method used.

1. Pour 25 cm^3 of the acid into a conical flask.
2. Weigh 0.10 g of copper carbonate.
3. Remove the stopper and add the copper carbonate to the flask.
4. Quickly replace the stopper.
5. Record the maximum volume of gas collected in the gas syringe.
6. Repeat steps 1 to 5 with different masses of copper carbonate.

(a) **Figure 2** shows the gas syringe during the experiment.

Figure 2



What is the reading on the gas syringe?

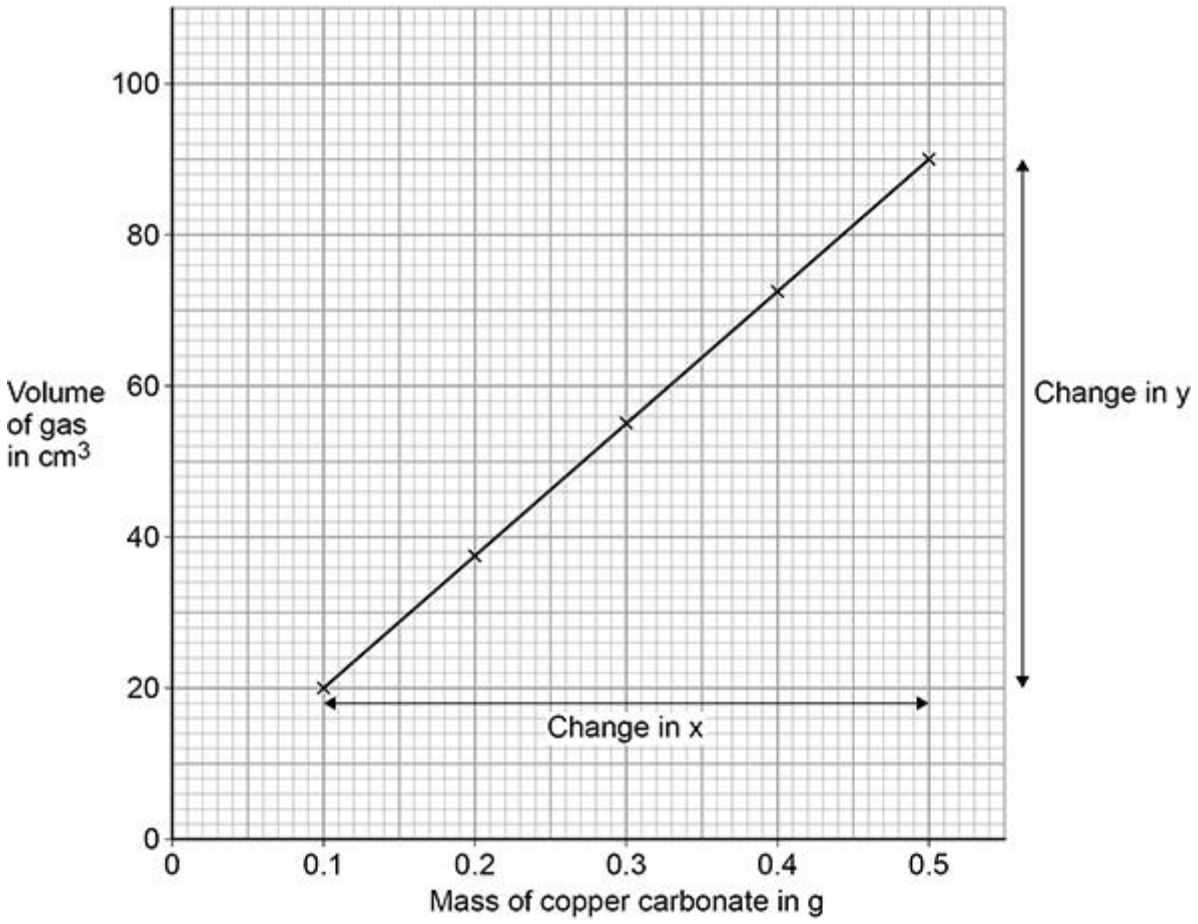
_____ cm^3

(1)

(b) The student plotted the results on a graph.

Figure 3 shows the student's graph.

Figure 3



Determine the gradient of the line of best fit.

You should:

- calculate the values of the change in y and the change in x
- calculate the gradient of the line of best fit.

Change in y = _____ cm^3

Change in x = _____ g

Gradient _____

Gradient = _____ cm^3/g

_____

(4)

(c) Copper chloride was produced in the reaction. Which acid reacts with copper carbonate to produce copper chloride? Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

(1)

(d) The reaction between copper carbonate and the acid produced a gas. What was the gas?

Tick (✓) **one** box.

Carbon dioxide ☐

Chlorine ☐

Hydrogen ☐

Oxygen ☐

(1)

A different student produced a pure, dry sample of copper chloride using the same reaction. This is the method used.

1. Add excess copper carbonate to the acid.
2. Filter the mixture.
3. Heat the solution gently until crystals start to form.
4. Leave for 24 hours.
5. Remove the crystals.
6. Rinse with water and dry the crystals.

(e) Why was the solution heated gently in **step 3**? Tick (✓) **one** box.

To evaporate acid ☐

To evaporate copper carbonate ☐

To evaporate water ☐

(1)

(f) How should the solution be heated gently in **step 3**?

_____

_____

(1)

(Total 9 marks)

Q3. This question is about chemical reactions and electricity.

(a) Electrolysis and chemical cells both involve chemical reactions and electricity. Explain the difference between the processes in electrolysis and in a chemical cell.

_____

_____

_____

_____

(2)

(b) A teacher demonstrates the electrolysis of molten lead bromide. Bromine is produced at the positive electrode. Complete the half equation for the production of bromine. You should balance the half equation.

$$Br^- \rightarrow \quad + \quad$$

(2)

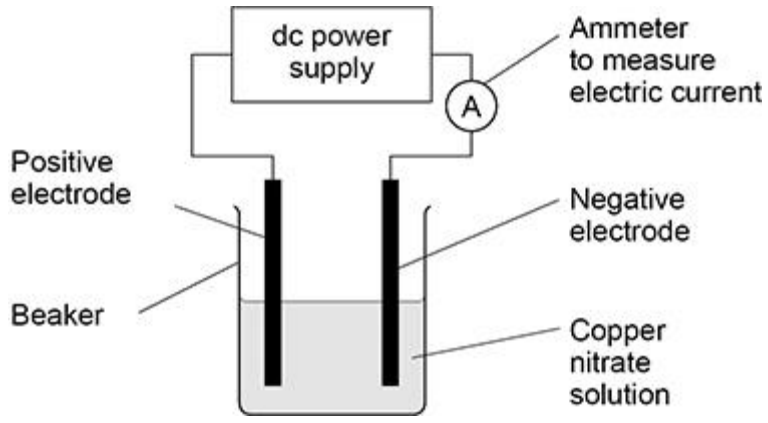
(c) Two aqueous salt solutions are electrolysed using inert electrodes. Complete the table below to show the product at each electrode.

Salt solution	**Product at positive electrode**	**Product at negative electrode**
Copper nitrate		copper
Potassium iodide		

(3)

Some students investigated the electrolysis of copper nitrate solution using inert electrodes. **Figure 1** shows the apparatus.

Figure 1



The students investigated how the mass of copper produced at the negative electrode varied with:

- time
- current.

This is the method used.

1. Weigh the negative electrode.
2. Set up the apparatus shown in **Figure 1**.
3. Adjust the power supply until the ammeter shows a current of 0.3 A
4. Switch off the power supply after 5 minutes.
5. Rinse the negative electrode with water and allow to dry.
6. Reweigh the negative electrode.
7. Repeat steps 1 to 6 for different times.
8. Repeat steps 1 to 7 at different currents.

(d) Some of the copper produced did not stick to the negative electrode but fell to the bottom of the beaker. Suggest how the students could find the total mass of copper produced.

_____

_____

_____

_____

_____

_____

_____

_____

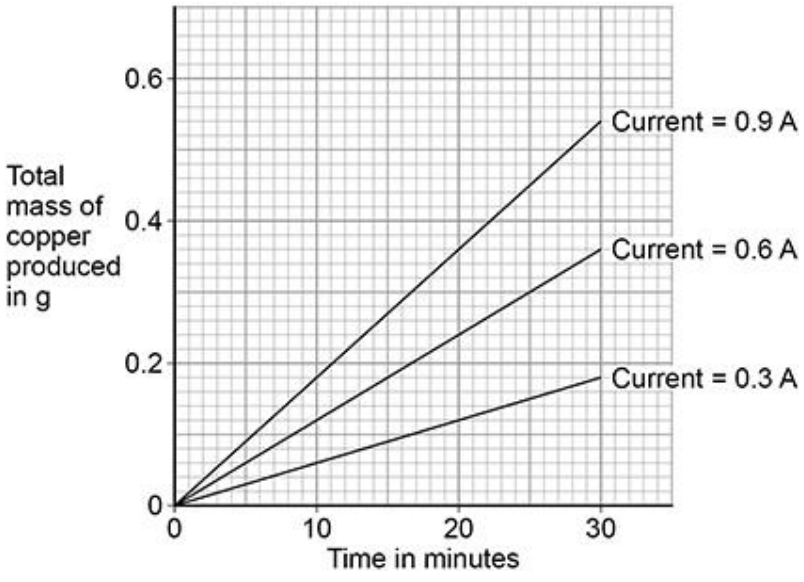
_____

_____

(4)

The students plotted their results on a graph. **Figure 2** shows the graph.

Figure 2



A student correctly concluded that the total mass of copper produced is directly proportional both to the time and to the current.

(e) How do the results in **Figure 2** support the conclusion that the total mass of copper produced is directly proportional to the time?

_____

_____

(1)

(f) How do the results in **Figure 2** support the conclusion that the total mass of copper produced is directly proportional to the current?

Use data from **Figure 2** in your answer.

_____

_____

(1)

(g) Copper nitrate solution is blue.

Suggest why the blue colour of the copper nitrate solution fades during the electrolysis.

_____

_____

(1)

(h) Determine the number of atoms of copper produced when copper nitrate solution is electrolysed for 20 minutes at a current of 0.6 A

Give your answer to 3 significant figures.

Use **Figure 2**.

Relative atomic mass (A_r): Cu = 63.5

The Avogadro constant = 6.02×10^{23} per mole

_____

_____

_____

_____

_____

_____

Number of atoms (3 significant figures) = _____

(3)

(Total 17 marks)

Q4. Cells contain chemicals which react to produce electricity.

(a) Why can a rechargeable cell be recharged?

_____

_____

(1)

(b) Give **two** factors that affect the voltage produced by a cell.

1. _____

2. _____

(2)

(c) Balance the half-equation for the reaction occurring at an electrode in one type of hydrogen fuel cell.

$$H_2 \quad + \quad OH^- \quad \longrightarrow \quad H_2O \quad + \quad e^-$$

(1)

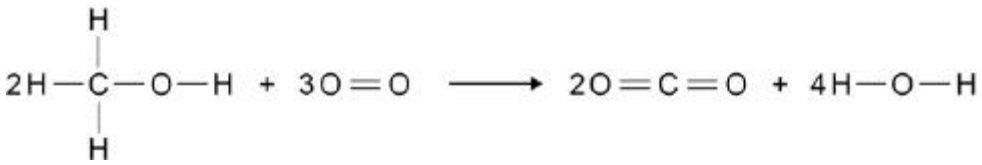
(d) Why is the fuel cell in Question (c) described as an alkaline fuel cell?

_____

_____

(1)

(e) Another type of fuel cell uses methanol instead of hydrogen. The diagram represents the reaction in this fuel cell.



The table shows the bond energies for the reaction.

	C–H	**C–O**	**O–H**	**O=O**	**C=O**
Bond energy in kJ / mol	412	360	464	498	805

Calculate the overall energy change for the reaction. Use the diagram and table above.

_____

_____

_____

_____

Overall energy change = _____ kJ / mol

(3)

(Total 8 marks)

Q1. (a) $\frac{54 + 50 + 55}{3}$

1

= 53 (°C)

*if no other mark awarded allow **1** mark for* $\frac{54 + 50 + 37 + 55}{4}$ *= 49 (°C)*

1

(b) (most reactive) magnesium zinc
(least reactive) cobalt

*allow ecf from question **(a)***

1

(c) (18 ±) 2 (°C)

1

(d) control

1

(e) use the same mass of metal / powder

1

(f) (A) progress of reaction

1

(B) activation energy

1

(C) products

1

[9]

Q2. (a) 48 (cm^3)

1

(b) (change in y =) 70 (cm^3)

1

(change in x =) 0.4 (g)

1

(gradient =) $\frac{70}{0.4}$ *allow correct use of incorrectly derived values for change in y and / or change in x*

1

= 175 (cm^3/g)

1

(c) hydrochloric acid

1

(d) carbon dioxide

1

(e) to evaporate water

1

(f) using a (boiling) water bath
or
using an electric heater

1

[9]

Q3. (a) electrolysis uses electricity to produce a chemical reaction

allow voltage for electricity
allow potential difference for electricity
allow (electrical) current for electricity
allow electrolysis uses electricity to decompose a compound / electrolyte

1

(but) cells use a chemical reaction to produce electricity

1

(b) $2Br^- \rightarrow Br_2 + 2e^-$

allow multiples
*allow **1** mark for Br_2 **and** e^-*

2

(c)

Salt solution	**Product at positive electrode**	**Product at negative electrode**
(copper nitrate)	oxygen (1)	(copper)
(potassium iodide)	iodine (1)	hydrogen (1)

1
2

(d) filter the mixture

1

wash and dry the copper / residue

1

weigh the copper collected

1

add to the increase in mass of the electrode

1

(e) (for given current) straight line through the origin

allow (for given current) when time doubles, mass doubles

1

(f) (for given time) when current doubles, mass doubles with supporting data

1

(g) copper ions are discharged (from the solution)

allow the solution becomes less concentrated

allow copper ions are removed (from the solution)

allow copper ions are used up (from the solution)

1

(h) (number of moles = $\frac{0.24}{63.5}$ =)
3.78×10^{-3} **or** 0.00378

1

(number of atoms =)
$0.00378 \times 6.02 \times 10^{23}$

allow correct use of an incorrectly calculated number of moles

1

$= 2.28 \times 10^{21}$

allow a correct evaluation to 3 significant figures of an incorrect expression which involves only a mass from the graph, the A_r of copper and the Avogadro constant

1

[17]

Q4. (a) the chemical reaction is reversible

1

(b) any **two** from:
- type of electrode
- electrolyte
- concentration of electrolyte
- temperature

2

(c) $H_2 + \mathbf{2}OH^- \rightarrow \mathbf{2}H_2O + \mathbf{2}\ e^-$ *allow multiples*

1

(d) contains OH^- ions

1

(e) (bonds broken)

((6 × 412) + (2 × 360) + (2 × 464) + (3 × 498)) = 5614

1

(bonds made)
((4 × 805) + (8 × 464)) = 6932

1

(overall energy change)
(6932 − 5614) = −1318 (kJ / mol)

allow ecf from marking point 1 and / or marking point 2

1

*an answer of 1318 (kJ / mol) scores **3** marks*

[8]