Combined Science
Past Paper Practice

5.3 Quantitative Chemistry

Q1.

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

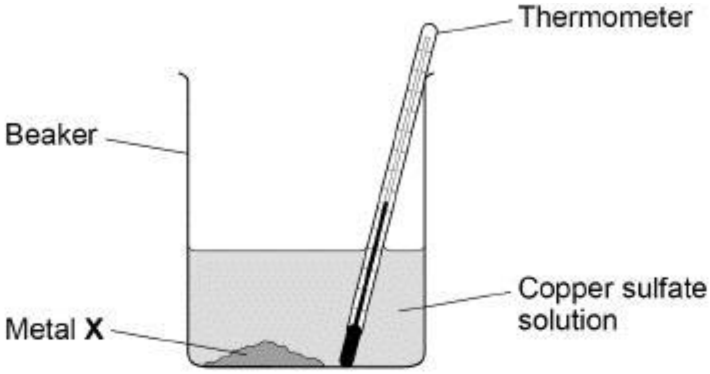
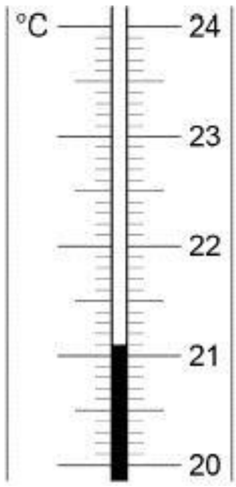


Figure 2 shows the thermometer reading of the copper sulfate solution at the start of the investigation.

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.

____

____

____

____

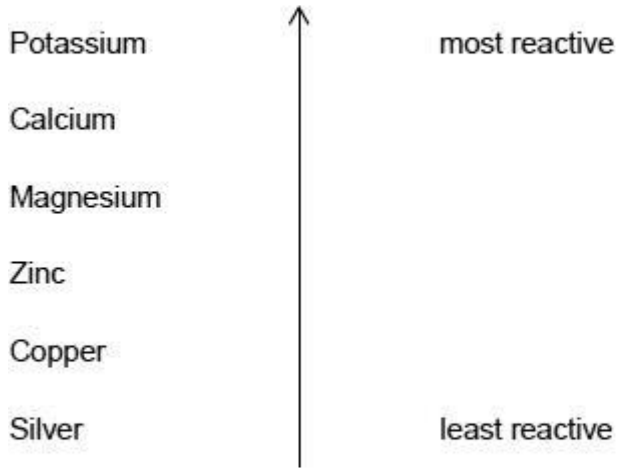
Mean temperature change = ______________ °C

(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)

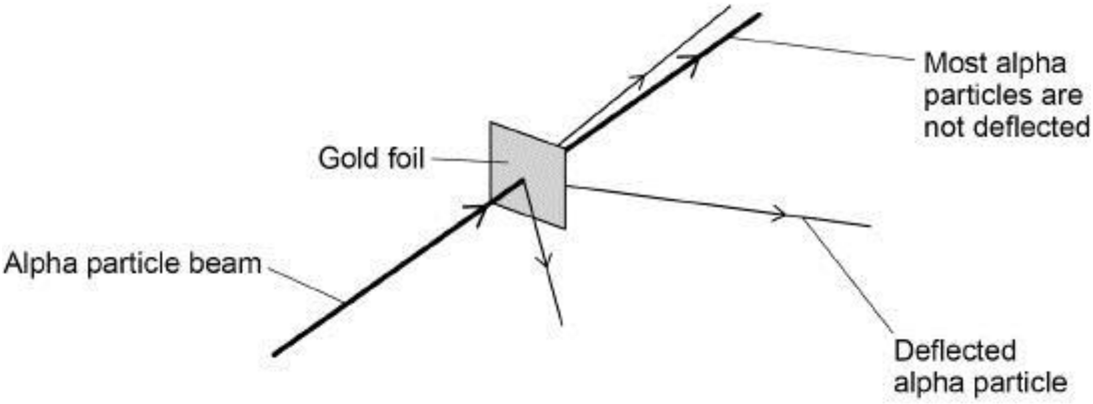
Q2.

This question is about gold and compounds of gold.

In the alpha particle scattering experiment alpha particles are fired at gold foil.

Alpha particles are positively charged.

The diagram below shows the results.



(a) Some alpha particles are deflected.

Complete the sentence.

Choose the answer from the box.

negatively charged	**not charged**	**positively charged**

Some alpha particles are deflected because the nucleus of the atom is ____________________.

(1)

(b) Why are most alpha particles **not** deflected?

Tick (✓) **one** box.

The atom is a tiny sphere that cannot be divided.	☐
The atom is mainly empty space.	☐
The electrons orbit the nucleus at specific distances.	☐

(1)

(c) What was **one** conclusion from the alpha particle scattering experiment?

Tick (✓) **one** box.

The mass is concentrated at the centre of the atom. ☐

The mass is concentrated at the edge of the atom. ☐

The mass is spread evenly throughout the atom. ☐

(1)

Gold reacts with the elements in Group 7 of the periodic table.

(d) What are Group 7 elements known as?

Tick (✓) **one** box.

Alkali metals ☐

Halogens ☐

Noble gases ☐

(1)

(e) Fluorine, chlorine and bromine react with gold.

Which element will be the most reactive with gold?

Tick (✓) **one** box.

Fluorine ☐ Chlorine ☐ Bromine ☐

(1)

(f) 3.94 g of gold reacts with chlorine to produce 6.07 g of gold chloride.

The word equation for the reaction is:

gold + chlorine → gold chloride

Calculate the mass of chlorine that reacts with 3.94 g of gold.

____

____

Mass = ________________ g

(1)

(g) Calculate the relative formula mass (M_r) of gold chloride ($AuCl_3$).

Relative atomic masses (A_r): Cl = 35.5 Au = 197

___

___

___

___

Relative formula mass (M_r) = ________________

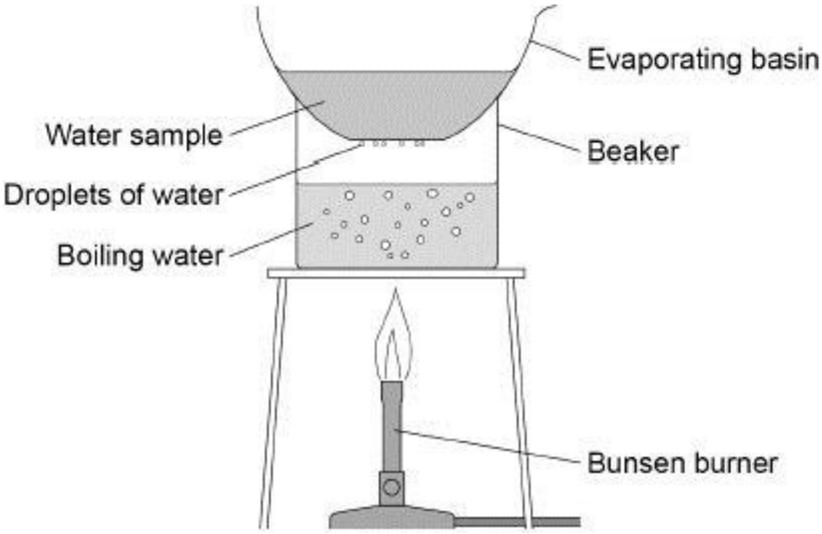
(2)

(Total 8 marks)

Q3.

A student investigated the mass of dissolved solids in water samples.

The diagram below shows the apparatus used.



This is the method used.

1. Record the mass of a dry evaporating basin.
2. Pour 25 cm^3 of the water sample into the evaporating basin.
3. Place the evaporating basin on the beaker for 10 minutes.
4. Record the mass of the evaporating basin and contents.

(a) What is used to find the mass of the evaporating basin?

Tick (✓) **one** box.

Balance	☐
Beaker	☐
Measuring cylinder	☐
Thermometer	☐

(1)

One error is that droplets of water collect on the bottom of the evaporating basin.

(b) Suggest how this error affects the mass of the evaporating basin and contents.

____

____

(1)

(c) How can this error be corrected?

___

___

(1)

(d) Another error in the method is that not all the water was removed from the water sample.

How can this error be corrected?

Tick (✓) **one** box.

Add more boiling water to the beaker.	☐
Heat until the mass of the evaporating basin and contents is constant.	☐
Stir the water sample in the evaporating basin with a glass rod.	☐

(1)

(e) The water in the water sample turns into steam.

What is the name of this process?

___

(1)

Another student did the experiment correctly with three water samples **A**, **B** and **C**.

The table below shows the results.

Water sample	**Mass of dissolved solids in g**			
	Test 1	**Test 2**	**Test 3**	**Mean**
A	0.23	0.23	0.20	**X**
B	0.03	0.07	0.02	0.04
C	1.45	1.60	1.45	1.50

(f) The range is the difference between the largest value and the smallest value.

Which water sample has the greatest range of results?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

(1)

(g) Calculate the mean mass **X** for water sample **A**.

Use table above.

____

____

____

____

X = ________________ g

(2)

(h) What is the dependent variable in this experiment?

Tick (✓) **one** box.

Mass of dissolved solids ☐

Time taken for water to heat ☐

Type of water sample ☐

Volume of boiling water ☐

(1)

(i) A different water sample contains 3.6 g of dissolved solids in 150 cm^3

Calculate the mass of dissolved solids in 25 cm^3 of this sample.

Mass = ________________ g

(2)

(Total 11 marks)

Q4.

This question is about Group 1 elements.

(a) Sodium reacts with chlorine to produce sodium chloride.

Balance the equation for the reaction.

$$\_\_\_\_\_\_ Na + Cl_2 \rightarrow \_\_\_\_\_\_ NaCl$$

(1)

(b) 4.6 g of sodium reacts with chlorine to produce 11.7 g of sodium chloride.

What mass of chlorine reacted?

____

____

Mass of chlorine = ____________________ g

(1)

(c) A teacher puts hot sodium into a gas jar of chlorine.

The changes seen before, during and after this reaction were observed.

Complete the sentences.

Choose the answers from the box.

colourless	**green**	**lilac**	**silver**	**white**
		yellow		

Sodium is a _________________ solid.

Chlorine is a _______________ gas.

The hot sodium burns with a _______________ flame.

The product sodium chloride is a _______________ solid.

(4)

(d) Sodium chloride (NaCl) is an ionic compound.

Write the formulae of the ions in sodium chloride.

Sodium ion _________________

Chloride ion _______________

(2)

(e) Complete the sentence.

Choose the answer from the box.

an atom	**an electron**	**a neutron**	**a proton**

Potassium is more reactive than sodium.

This is because potassium loses ____________________ more easily than sodium.

(1)

(f) How does the size of a potassium atom compare with the size of a sodium atom?

Give a reason for your answer.

____

Reason ____

____

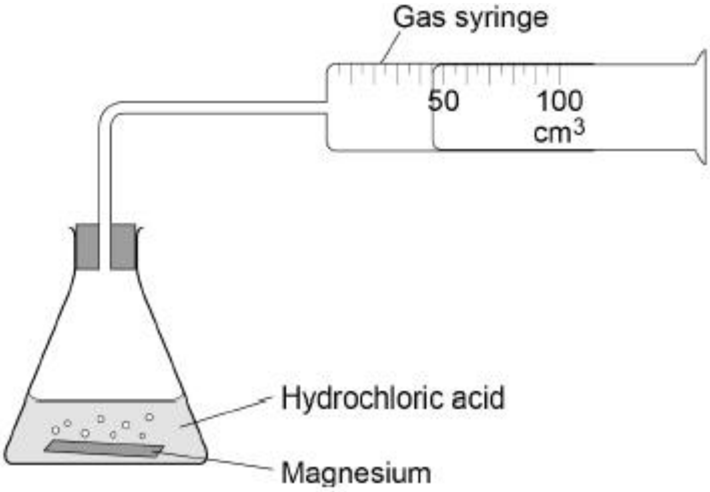
____

(2)
(Total 11 marks)

Q5.

A student investigated the rate of the reaction between magnesium and hydrochloric acid.

The diagram shows the apparatus the student used.



(a) Balance the equation for the reaction.

$$Mg + \_\_\_\_\_\_ HCl \rightarrow MgCl_2 + H_2$$

(1)

(b) The student used 50 cm³ of hydrochloric acid.

Which apparatus would measure 50 cm³ of hydrochloric acid with the greatest accuracy?

Tick (✓) **one** box.

50 cm³ beaker	☐
50 cm³ conical flask	☐
50 cm³ measuring cylinder	☐

(1)

(c) The student measured the volume of gas produced every 20 seconds for 2 minutes.

The volume of gas was zero at the start of the experiment.

The measured volumes of gas were:

26 cm^3 38 cm^3 47 cm^3 55 cm^3 59 cm^3 60 cm^3

Complete the table to show these results.

0	0

(4)

(d) The volumes of gas were lower than expected.

Suggest **one** reason.

____

____

(1)

(e) The student repeated the experiment using different concentrations of hydrochloric acid.

Give **two** variables the student should keep the same.

1 ____

2 ____

(2)

(f) Complete the sentences.

As the concentration of the hydrochloric acid increased, the rate of the reaction ________________________ .

This is because there were more acid ________________________ in each cubic centimetre (cm^3).

So the collisions happened more ________________________ .

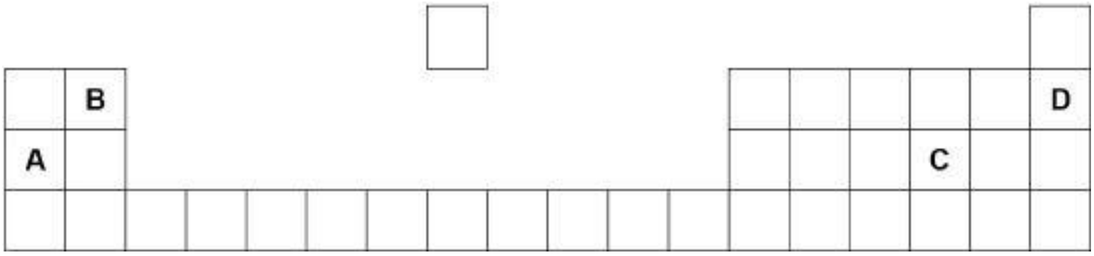
(3)

Q6.

This question is about the elements in Group 2 of the periodic table.

(a) **Figure 1** shows the positions of four elements, **A**, **B**, **C**, and **D**, in the periodic table.

Figure 1



Which element is in Group 2?

Tick **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

Group 2 metal carbonates break down when heated to produce a metal oxide and a gas.

metal carbonate ⟶ metal oxide + gas

(b) Name the two products when calcium carbonate ($CaCO_3$) is heated.

________________________ and ________________________

(2)

(c) What type of reaction happens when a compound breaks down?

Tick **one** box.

burning ☐

decomposition ☐

neutralisation ☐

reduction ☐

(1)

(d) The metal carbonate takes in energy from the surroundings to break down.

What type of reaction takes in energy from the surroundings?

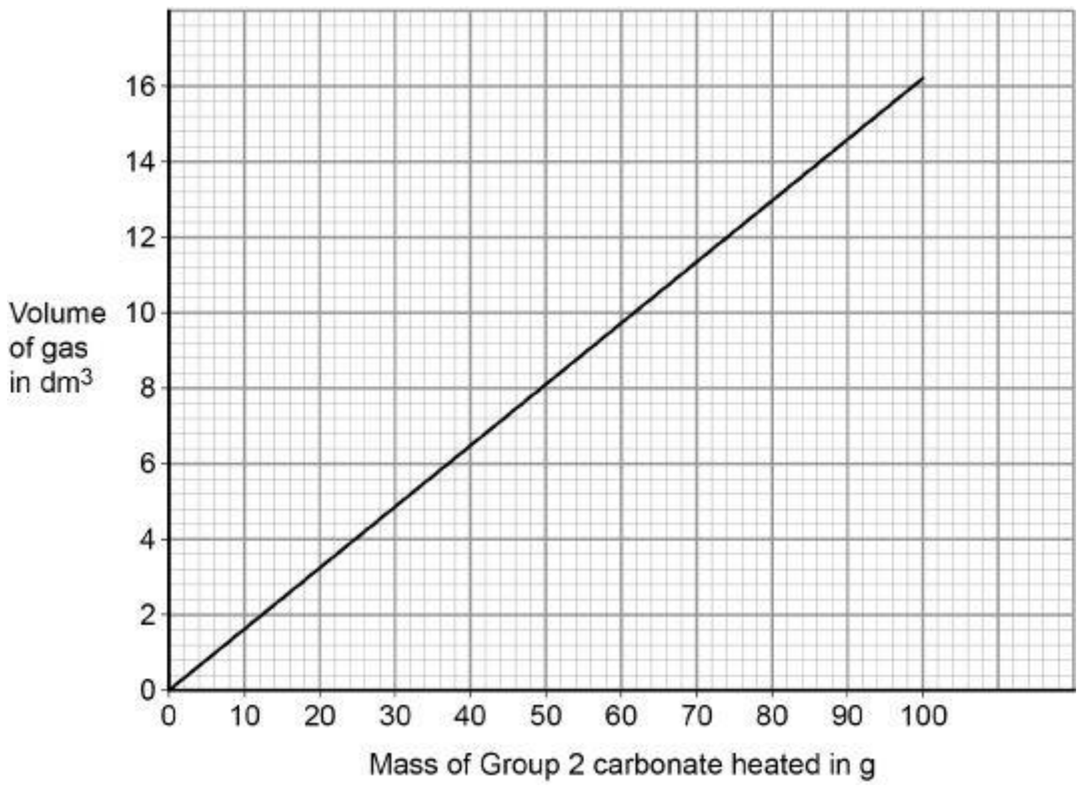
Tick **one** box.

combustion	☐
electrolysis	☐
endothermic	☐
exothermic	☐

(1)

(e) **Figure 2** shows the volume of gas produced when a Group 2 metal carbonate is heated.

Figure 2



The student collected 5.2 dm^3 of gas.

What mass of the Group 2 metal carbonate is heated?

Mass = ________________________ g

(1)

(f) Calculate the mass of the Group 2 carbonate needed to produce 24 dm^3 of gas.

Use your answer from part **(e)** to help you.

___

___

___

___

Mass = ______________________ g

(2)

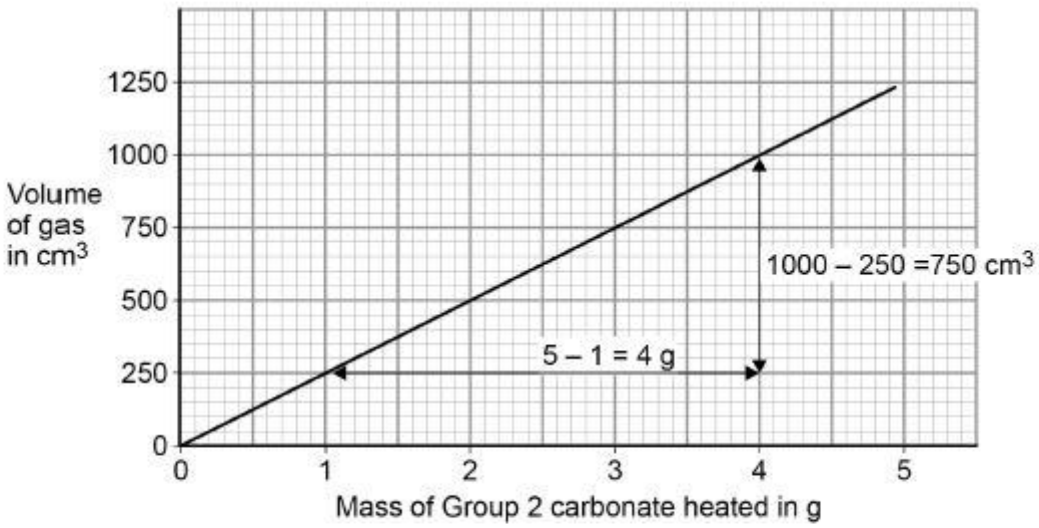
(g) A student heated different masses of a Group 2 carbonate. The student measured the volume of gas produced.

Figure 3 shows a graph of the student's results.

The student calculates the gradient of the line in **Figure 3**

The student makes **two** mistakes.

Figure 3



$$\text{Correct formula for gradient} = \frac{\text{Increase in volume of gas}}{\text{Increase in mass of Group 2 metal carbonate heated}}$$

$$\text{Student's calculation} = \frac{4}{750} = 0.00533 \text{ cm}^3 \text{ per g}$$

Identify the **two** mistakes the student makes.

Calculate the correct gradient of the line.

Mistake 1 ____

____

Mistake 2 ____

____

Calculation ____

____

Gradient = ____________________ cm^3 per g

(4)

(h) A student repeated the experiment with a different Group 2 metal carbonate (**X**CO_3).

The relative formula mass (M_r) of **X**CO_3 is 84

Relative atomic masses (A_r): C = 12 O = 16

Calculate the relative atomic mass (A_r) of **X**.

Name metal **X**.

Use the periodic table.

____

____

____

____

Relative atomic mass (A_r) = ____________________

Metal **X** is ____________________

(4)

(Total 16 marks)

Q7.

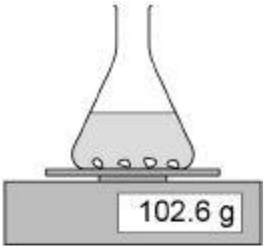
A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10.0 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid and start a timer.
3. Record the mass lost from the flask every 10 seconds.
4. Repeat steps 1 to 3 with different sizes of marble chips.

Figure 1 shows the apparatus.

Figure 1



(a) Draw **one** line from each type of variable to the correct example of the variable.

Type of variable	**Example of variable**
	Mass lost from flask
Independent	Size of flask
	Size of marble chips
Control	Time taken
	Volume of acid

(2)

(b) The equation for the reaction is:

$$CaCO_3(s) + 2HCl(aq) \quad CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Name the **three** products.

1. ________________________________

2. ________________________________

3. ________________________________

(2)

(c) Another student suggests putting some cotton wool in the top of the flask.

Suggest why this improves the investigation.

____

____

(1)

(d) The reaction produces 1.6 g of gas in 30 seconds.

Calculate the mean rate of the reaction in the first 30 seconds.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{mass of product produced in grams}}{\text{time in seconds}}$$

____

____

Mean rate of reaction = ___________________________

(1)

(e) What is the unit for the mean rate of reaction calculated in part **(d)**?

Tick **one** box.

g ☐ g/s ☐ s ☐ s/g ☐

(1)

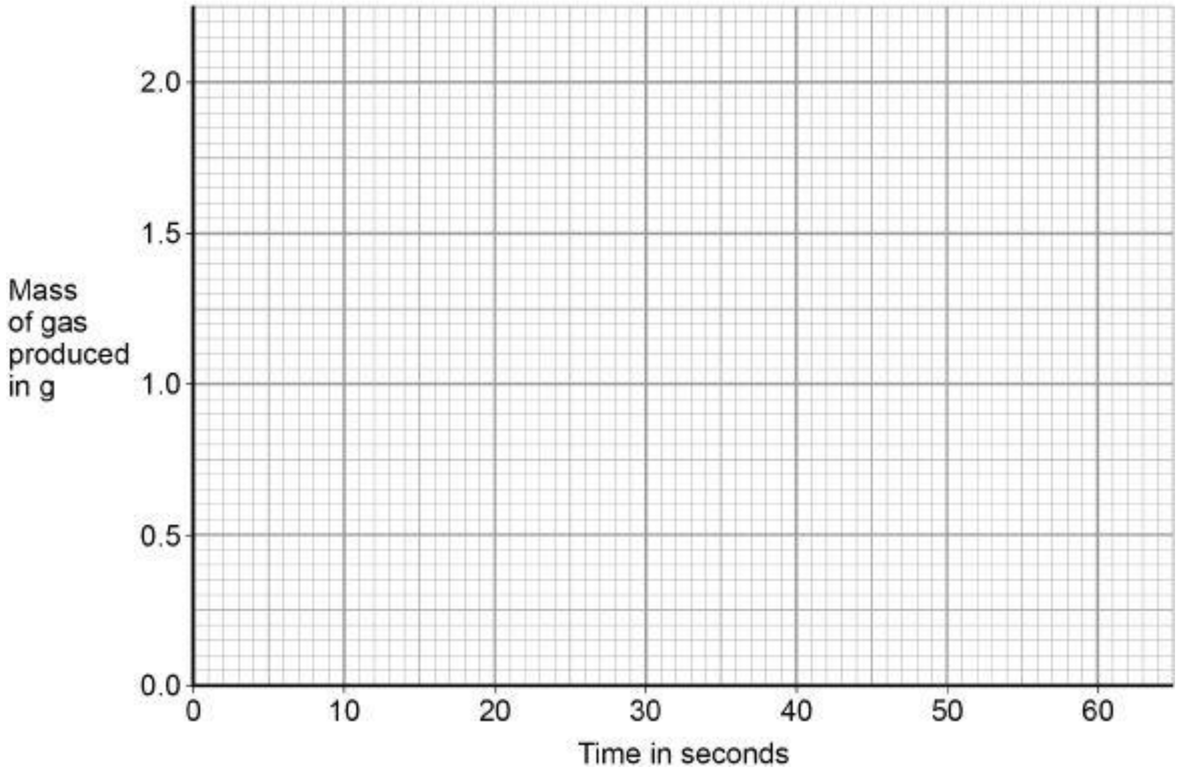
(f) The table below shows the student's results.

Time in seconds	Mass of gas produced in g
0	0.0
10	0.8
20	0.6
30	1.6
40	1.8
50	2.0
60	2.0

Plot the data from the table above on **Figure 2**

Draw a line of best fit.

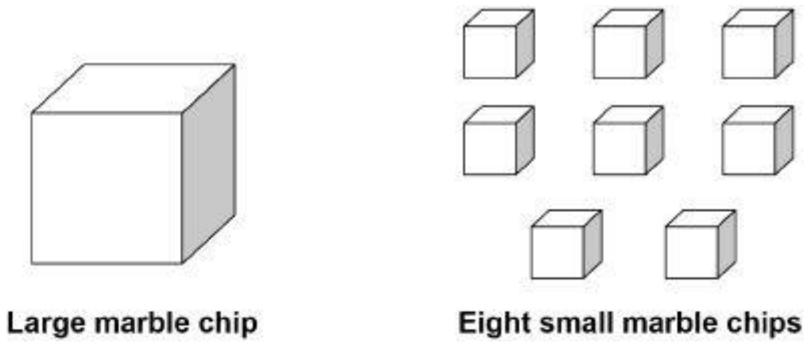
Figure 2



(3)

(g) **Figure 3** shows a large marble chip and eight small marble chips.

Figure 3



The large marble chip has the same total volume as the eight small marble chips, but a different surface area.

Why do the eight small marble chips react faster than the large marble chip?

Tick **one** box.

The eight small marble chips have a larger surface area, so less frequent collisions.	☐
The eight small marble chips have a larger surface area, so more frequent collisions.	☐
The eight small marble chips have a smaller surface area, so less frequent collisions.	☐
The eight small marble chips have a smaller surface area, so more frequent collisions.	☐

(1)

(Total 11 marks)

Q8.

Some students investigated the thermal decomposition of metal carbonates.

The word equation for the reaction is:

metal carbonate → metal oxide + carbon dioxide

The students made the following hypothesis:

‘When heated the same mass of any metal carbonate produces the same mass of carbon dioxide.’

The students heated a test tube containing copper carbonate.

The table below shows their results.

Time the test tube containing copper carbonate was heated in mins	0	2	4	6
Mass of test tube and contents in g	17.7	17.1	17.0	17.0

Plan a method the students could use to test their hypothesis.

You should show how the students use their results to test the hypothesis.

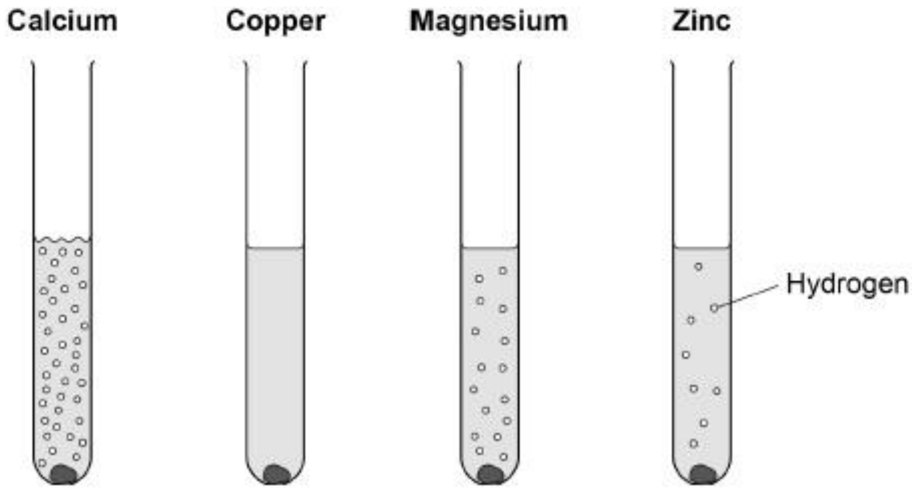
You do **not** need to write about safety precautions.

(Total 6 marks)

Q9.

This question is about reactions of metals.

The diagram shows what happens when calcium, copper, magnesium and zinc are added to hydrochloric acid.



(a) What is the order of decreasing reactivity of these four metals?

Tick (✓) **one** box.

Zn Ca Cu Mg	☐
Ca Cu Mg Zn	☐
Ca Zn Ca Mg	☐
Ca Mg Zn Cu	☐

(1)

A student wants to make a fair comparison of the reactivity of the metals with hydrochloric acid.

(b) Name **two** variables that must be kept constant.

1 ____

____

2 ____

____

(2)

(c) What is the independent variable in this reaction?

____

____

(1)

(d) Predict the reactivity of beryllium compared with magnesium.

Give a reason for your answer.

Use the periodic table.

____

Reason ____

____

____

(2)

(e) A solution of hydrochloric acid contains 3.2 g of hydrogen chloride in 50 cm^3

Calculate the concentration of hydrogen chloride in g per dm^3

____

____

____

____

Concentration = ____________________ g per dm^3

(3)

(Total 9 marks)

Q10.

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)

Q11.

Water that is safe to drink contains dissolved substances.

(a) What do we call water that is safe to drink?

Tick (✓) **one** box.

Desalinated ☐

Filtered ☐

Fresh ☐

Potable ☐

(1)

(b) Describe a test for pure water.

Give the result of the test if the water is pure.

Test ______________________________

Result ______________________________

____

____

(2)

(c) Describe a method to determine the mass of dissolved solids in a 100 cm^3 sample of river water.

____

____

____

____

____

____

____

____

____

____

______________________________ **(4)**

(d) A sample of river water contains 125 mg per dm^3 of dissolved solids.

Calculate the mass of dissolved solids in grams in 250 cm^3 of this sample of river water.

Give your answer to 2 significant figures.

____

____

____

____

____

____

____

____

Mass of dissolved solids = ____________________________ g

(4)

(e) A water company allows a maximum of 500 mg per dm^3 of sulfate ions in drinking water.

A sample of drinking water contains 44 mg per dm^3 of sulfate ions.

Calculate the percentage (%) of the maximum allowed mass of sulfate ions in the sample of drinking water.

____

____

____

____

Percentage (%) of the maximum allowed mass = ________________ %

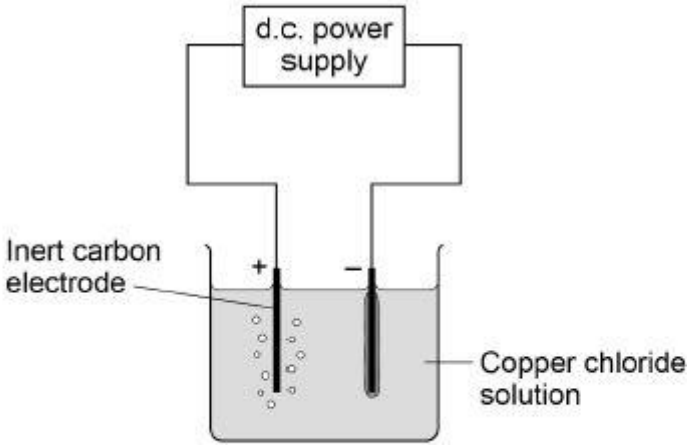
(2)

(Total 13 marks)

Q12. 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 ☐

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)

Q13.

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)

Q14.

A student investigated the temperature change when magnesium was added to copper sulfate solution.

This is the method used.

1. Pour 30 cm^3 of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of copper sulfate solution every minute for 3 minutes.
3. Add magnesium on the fourth minute.
4. Measure the temperature of the mixture at 5 minutes and then every minute up to 14 minutes.

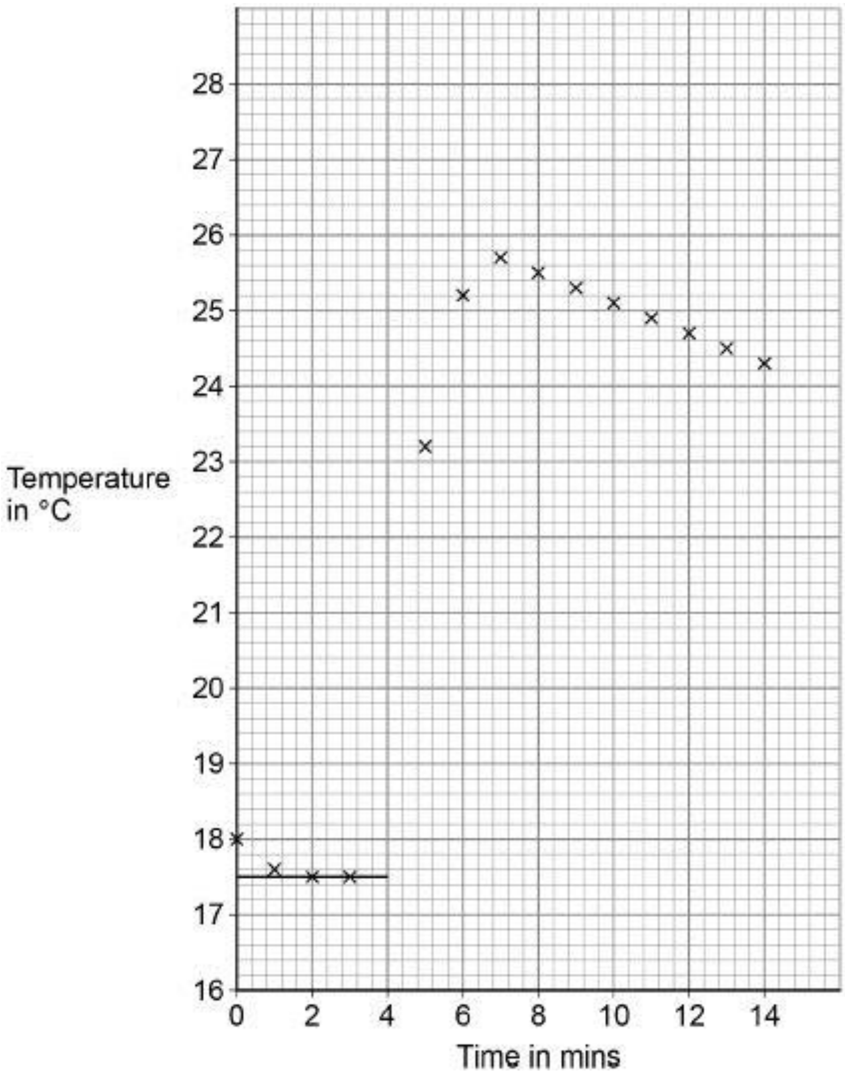
(a) What is the dependent variable in this investigation?

____

(1)

The student used the results to plot a graph.

The image below shows the graph.



(b) Suggest why the copper sulfate solution was left for four minutes before adding the magnesium.

___

___

(1)

(c) Complete the graph above by:

- drawing a line of best fit through all the points after 7 minutes
- extending the line back to 4 minutes.

(2)

(d) The temperature change for the reaction is the temperature difference between the two graph lines at 4 minutes.

Determine the temperature change for the reaction.

Use the graph above.

___

___

Temperature change = ________________ °C

(2)

(e) Explain why the temperature of the mixture decreases after 7 minutes.

___

___

___

___

(2)

(f) The student repeated the experiment with an unknown metal **Q** instead of magnesium.

All the other variables were kept the same.

The student recorded a smaller temperature change.

Suggest the identity of metal **Q**.

Give **one** reason for your answer.

Metal **Q** ____________________

Reason ____

___

(2)

(g) A copper sulfate solution contained 0.100 moles of copper sulfate dissolved in 0.500 dm^3 of water.

Calculate the mass of copper sulfate in 30.0 cm^3 of this solution.

Relative formula mass (M_r): $CuSO_4$ = 159.5

____

____

____

____

____

____

Mass = _______________ g

(4)

(Total 14 marks)

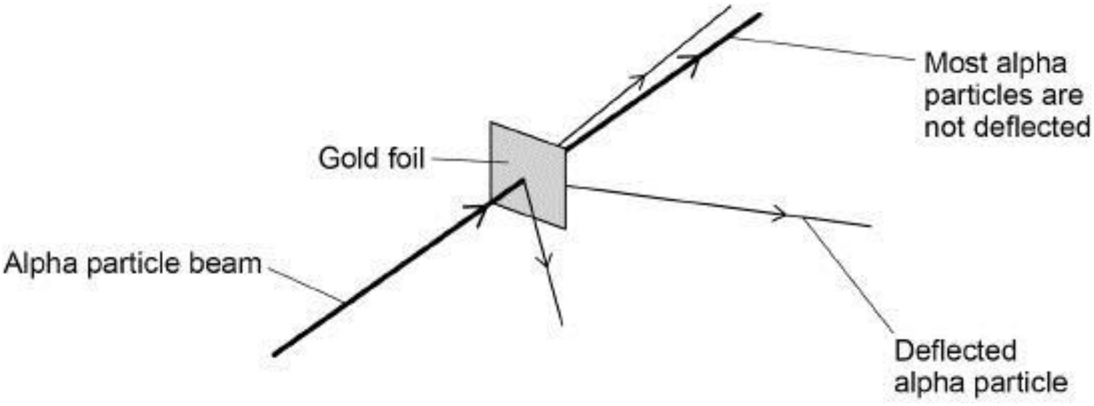
Q15.

This question is about gold and compounds of gold.

(a) In the alpha particle scattering experiment alpha particles are fired at gold foil.

Alpha particles are positively charged.

The diagram below shows the results.



What **two** conclusions can be made from the results?

Tick (✓) **two** boxes.

Atoms are balls of positive charge with embedded electrons.	☐
Atoms are tiny spheres that cannot be divided.	☐
Atoms have a positively charged nucleus.	☐
Mass is concentrated in the nucleus in the centre of atoms.	☐
Neutrons exist within the nucleus.	☐

(2)

(b) The gold foil is:

- 4.00×10^{-7} metres thick
- 2400 atoms thick.

What is the diameter of one gold atom in metres?

Give your answer to 3 significant figures.

___

___

___

Diameter of one gold atom (3 significant figures) = ________________ m

(3)

(c) Gold reacts with the elements in Group 7 of the periodic table.

0.175 g of gold reacts with chlorine.

The equation for the reaction is:

$$2\ Au + 3\ Cl_2 \rightarrow 2\ AuCl_3$$

Calculate the mass of chlorine needed to react with 0.175 g of gold.

Give your answer in mg

Relative atomic masses (A_r): Cl = 35.5 Au = 197

Mass of chlorine = ________________ mg

(5)

(Total 10 marks)

Q16.

This question is about elements in the periodic table.

(a) What order did scientists use to arrange elements in early periodic tables?

____

____

(1)

(b) In the early periodic tables some elements were placed in the wrong groups.

Mendeleev overcame this in his periodic table.

Give **one** way Mendeleev did this.

____

____

(1)

The table shows the boiling points of fluorine, chlorine and bromine.

Element	**Boiling point in °C**
Fluorine	−186
Chlorine	−34
Bromine	+59

(c) Explain why the boiling points in the table are low.

____

____

____

____

(2)

(d) Explain the trend in the boiling points in the table above.

____

____

____

____

____

____

(3)

(e) Explain why neon is unreactive.

Give the electronic structure of neon in your answer.

___

___

___

___

(2)

(f) How many atoms are there in 1 g of argon?

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

Relative atomic mass (A_r): Ar = 40

___

___

___

___

Number of atoms in 1 g = ___

(2)

(Total 11 marks)

Q17.

This question is about oxygen (O_2) and sulfur dioxide (SO_2).

(a) Give the test and result for oxygen gas.

Test ____

Result ____

(2)

(b) The reaction between oxygen and sulfur dioxide is at equilibrium.

$$O_2(g) + 2\ SO_2(g) \rightleftharpoons 2\ SO_3(g)$$

Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

____

____

____

____

(2)

(c) Sulfur dioxide is an atmospheric pollutant.

Sulfur dioxide pollution is reduced by reacting calcium oxide with sulfur dioxide to produce calcium sulfite.

$$CaO + SO_2 \longrightarrow CaSO_3$$

7.00 g of calcium oxide reacts with an excess of sulfur dioxide.

Relative atomic masses (A_r): O = 16 S = 32 Ca = 40

Calculate the mass of calcium sulfite produced.

____

____

____

____

____

____

____

Mass of calcium sulfite produced = ______________________ g

(4)

(Total 8 marks)

Q18.

Group 2 metal carbonates thermally decompose to produce a metal oxide and a gas.

(a) Give the formula of each product when calcium carbonate ($CaCO_3$) is heated.

________________________________ and ________________________________

(2)

(b) The relative formula mass (M_r) of a Group 2 metal carbonate is 197

Relative atomic masses (A_r): C = 12 O = 16

Calculate the relative atomic mass (A_r) of the Group 2 metal in the metal carbonate.

Name the Group 2 metal.

____

____

____

____

____

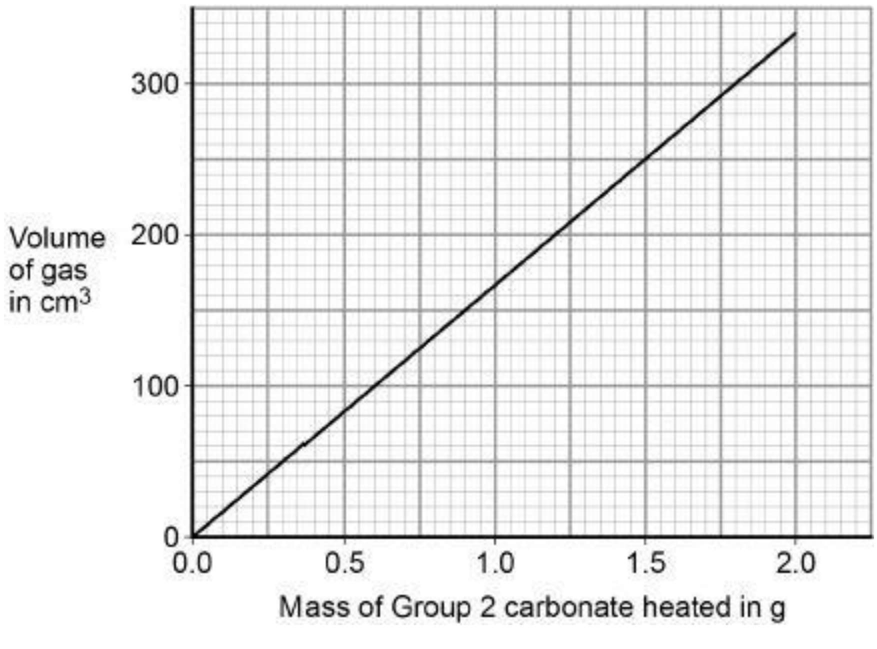
____

Relative atomic mass (A_r) = _________________________

Metal _________________________

(3)

The graph below shows the volume of gas produced when a different Group 2 carbonate, **W**, is heated.



(c) Calculate the gradient of the line in the graph above.

Give the unit.

____

____

____

____

____

____

____

____

Gradient ______________________

Unit ______________________

(3)

(d) 24 dm^3 of gas is produced when one mole of a Group 2 carbonate is heated.

Determine the relative formula mass of the Group 2 carbonate **W**.

Use the graph above.

____

____

____

____

____

____

____

____

____

____

____

____

Relative formula mass (M_r) = ______________________

(4)

(Total 12 marks)

Q19.

This question is about iron.

Iron reacts with dilute hydrochloric acid to produce iron chloride solution and one other product.

(a) Name the other product.

____

(1)

(b) Suggest how any unreacted iron can be separated from the mixture.

____

____

(1)

Magnesium reacts with iron chloride solution.

$$3\ Mg + 2\ FeCl_3 \longrightarrow 2\ Fe + 3\ MgCl_2$$

(c) 0.120 g of magnesium reacts with excess iron chloride solution.

Relative atomic masses (A_r): Mg = 24 Fe = 56

Calculate the mass of iron produced, in mg

____

____

____

____

____

____

____

____

____

____

Mass of iron = ______________________________ mg

(5)

(d) Explain which species is reduced in the reaction between magnesium and iron chloride.

$$3\ Mg + 2\ FeCl_3 \longrightarrow 2\ Fe + 3\ MgCl_2$$

Your answer should include the half equation for the reduction.

____

____

____

____

____

____

____

____

(3)

(Total 10 marks)

Q20.

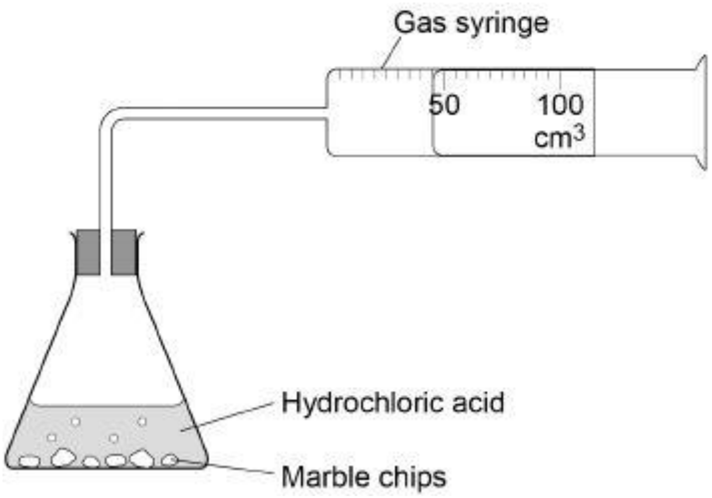
A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid, connect the gas syringe and start a timer.
3. Record the volume of gas produced every 10 seconds.

Figure 1 shows the apparatus.

Figure 1

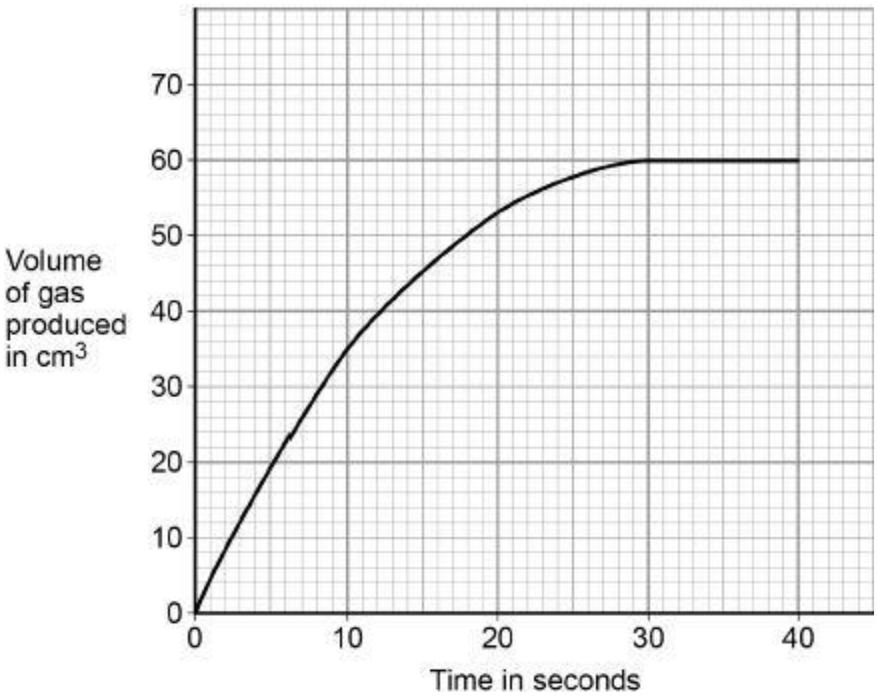


(a) Complete the equation for the reaction.

$CaCO_3$ + ________HCl ⟶ ________________________________

(2)

Figure 2 shows the student's results



(b) Describe the trend shown in **Figure 2**

Use values in your answer.

____

____

____

____

____

____

(3)

(c) Describe how you would use **Figure 2** to find the rate of the reaction at 15 seconds.

You do **not** need to do a calculation.

____

____

____

____

(2)

(d) Give the units for the rate of this reaction.

____

(1)

The table below shows the results of the investigation.

Relative size of marble chips	**Volume of gas produced in cm^3 after given time in seconds**					
	10 s	**20 s**	**30 s**	**40 s**	**50 s**	**60 s**
Small	35	53	60	60	60	60
Medium	21	39	51	58	60	60
Large	14	29	39	48	58	60

(e) Give **one** conclusion about how the size of the marble chips affects the rate of the reaction.

____

____

(1)

(f) Suggest why all three sizes of marble chips produce a maximum volume of 60 cm^3 of gas.

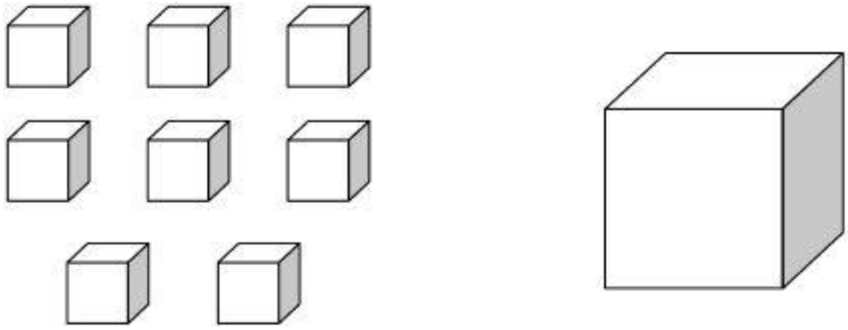
____

____

(1)

(g) **Figure 3** shows eight small cubes, each 1 cm × 1 cm × 1 cm, and one large cube, 2 cm × 2 cm × 2 cm

Figure 3



Total volume of small cubes = 8 cm^3 Volume of large cube = 8 cm^3

Total surface area of small cubes = 48 cm^2

Calculate the surface area of the large cube.

____

____

____

____

Surface area of the large cube = ____________________ cm^2

(2)

(h) Explain why the size of the marble chips affects the rate of the reaction.

Give your answer in terms of 'collision theory'.

____

____

____

____

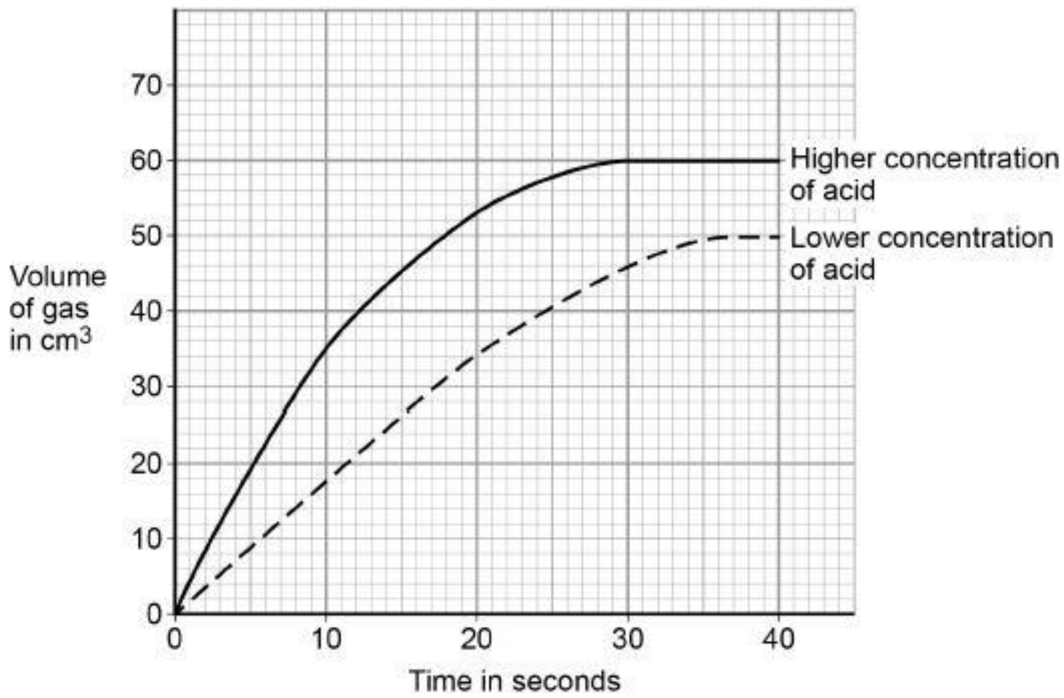
____

(2)

(i) The student repeated the investigation with small marble chips using hydrochloric acid with a lower concentration.

Figure 4 shows the volume of gas produced during the first 40 seconds.

Figure 4



Explain why the results for the lower concentration of acid are different from the results for the higher concentration of acid.

____

____

____

____

____

____

(3)

(Total 17 marks)

Q21.

Fertilisers are formulations.

(a) What is a formulation?

____

____

(1)

(b) A bag of fertiliser contains 14.52 kg of ammonium nitrate (NH_4NO_3).

Relative formula mass (M_r): NH_4NO_3 = 80

Calculate the number of moles of ammonium nitrate in the bag of fertiliser.

Give your answer in standard form to 2 significant figures.

____

____

____

____

____

____

____

____

Moles of ammonium nitrate = ____________________ mol

(4)

(c) The fertiliser also contains potassium chloride.

Explain why potassium chloride has a high melting point.

____

____

____

____

____

____

____

____

(4)

(Total 9 marks)

Q1.

(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]

Q2.

(a) positively charged 1

(b) the atom is mainly empty space. 1

(c) the mass is concentrated at the centre of the atom. 1

(d) halogens 1

(e) fluorine 1

(f) 2.13 (g) 1

(g) 197 + (3 × 35.5)
or
197 + 106.5 1

= 303.5 1

[8]

Q3.

(a) balance

1

(b) mass was greater / more than expected

1

(c) dry the bottom of the evaporating basin

or

use an electric heater

1

(d) heat until the mass of the evaporating basin and contents is constant.

1

(e) evaporation

ignore boiling

1

(f) **C**

1

(g)

$$\frac{0.23 + 0.23 + 0.20}{3} \textbf{ or } \frac{0.66}{3}$$

1

= 0.22 (g)

1

(h) mass of dissolved solids

1

(i)

$$\frac{25}{150} \times 3.6 \textbf{ or } \frac{1}{6} \times 3.6$$

1

= 0.6 (g)

1

[11]

Q4.

(a) $2\ Na + Cl2 \longrightarrow 2\ NaCl$

allow multiples

1

(b) 7.1 (g)

1

(c)

this order only

silver

1

green

allow yellow

1

yellow

allow white

1

white

1

(d) Na^+

1

Cl^-

1

if no other mark awarded allow ***1*** *mark for +(1) charge for sodium ion and –(1) charge for chloride ion*

(e) an electron

1

(f) potassium (atom) is larg<u>er</u>

1

potassium (atom) has more energy levels (of electrons)
or
potassium (atom) has more shells (of electrons)

do ***not*** *accept more outer shells*

1

[11]

Q5.

(a) 2

allow multiples of whole equation

1

(b) 50 cm^3 measuring cylinder

1

(c) headings: time **and** volume (of gas)

allow in either column

1

units: s **and** cm^3

allow any units of time and volume placed in relevant column

1

time values correct (and match units)

1

volume values match time values

ignore incorrect representation of time values

*if no other marks awarded allow **1** mark for time with correct units*
or
volume with correct units

1

(d) any **one** from:

- concentration of the acid was lower (than expected)
- some (gas) escaped
- impure magnesium
- temperature lower (than expected)

answers must relate to the diagram

ignore answers relating to amount or surface area or time

1

(e) any **two** from:

- length of magnesium
- or
- surface area of magnesium

allow mass of magnesium

allow same form of magnesium

allow same size of magnesium

- volume of acid

ignore concentration of hydrochloric acid

- temperature (of acid)

ignore room temperature

2

(f) increased

allow went up

allow got bigger

1

particles

allow ions or molecules

ignore concentration

1

frequently

allow often

1

[12]

Q6.

(a) B

1

(b) calcium oxide **or** CaO

1

carbon dioxide **or** CO_2

1

either order

(c) decomposition

1

(d) endothermic

1

(e) 32 (g)

allow 31−33 (g)

1

(f) $\frac{32}{5.2} \times 24$

1

148 (g)

allow a range 143−153 (g)

or

uses graph e.g. 12 dm^3 gives 74 (g) (1)

(then factors up so that 24 dm^3 gives) 148 (g) (1)

allow a range 143−153 (g)

1

*an answer of 148 (g) scores **2** marks*

*allow ecf from part **(e)***

(g) (mistakes)

increase in mass = 3 (not 4)

allow mistakes in either order

1

inserted numbers inversely into formula

allow numbers wrong way round

1

(calculation)

*an answer of 250 scores the **2** calculation marks*

1

$\text{gradient} = \frac{750}{3}$

allow $\frac{1000}{4}$

250 (cm^3 per g)

if no calculation marks awarded

allow $\frac{750}{4}$ **or** *187.5* **or** $\frac{3}{750}$

or *0.004 for* ***1*** *mark*

1

(h) 3 × 16 or 48

1

(48) + 12 or 60

allow their mass of oxygen + 12

1

84 − (60) **or** 24

allow 84 − their mass of carbonate

1

magnesium **or** Mg

magnesium ***or*** *Mg without working scores this mark*

1

an answer of 24 scores the ***3*** *calculation marks*

[16]

Q7.

(a) lines from:

- independent to size of marble chips **1**
- control to volume of acid **1**

ignore arrowheads

*do **not** accept if more than one line from one box*

(b) calcium chloride

carbon dioxide

*do **not** accept carbon oxide*

water

*do **not** accept hydrogen oxide*

2

*all three needed for **2** marks*
*allow **1** mark if two correct*

(c) stops loss of acid

allow stops loss of water / liquid
allow to ensure that only the gas escapes

*do **not** accept stops acid evaporating*

*do **not** accept stops gas / CO_2 / water vapour escaping*

1

(d) 0.053

allow 0.05
allow 0.053333…

*do **not** accept 0.052*
ignore units

1

(e) g/s

1

(f) all points correctly plotted

*allow **1** mark for 5 points correctly plotted*
allow ± ½ a small square

2

line of best fit

should be a curve nearer to (10,0.8) than the anomaly (20, 0.6) and through all other points

if plotting incorrect allow 1 mark for appropriate line of best fit through student's points

1

(g) the eight small marble chips have a larger surface area, so more frequent collisions

1

[11]

Q8.

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

Indicative content:

- weigh test tube
- add metal carbonate
- weigh test tube and metal carbonate

- heat
- allow to cool
- weigh test tube and metal oxide
- repeat (heat, cool and weigh) until no change in mass

- determine mass of metal carbonate used
- determine mass of carbon dioxide produced

- repeat with different metal carbonate(s)

an alternative method can be based on any mass of metal carbonates and at end divide by this mass to find mass carbon dioxide per gram metal carbonate

level 3 change in mass is determined for at least one other carbonate

[6]

Q9.

(a) Ca Mg Zn Cu

1

(b) any **two** from:

- mass (of metal / element)
  allow weight
- surface area (of metal / element)
  ignore size
  ignore length
- concentration (of acid)
  ignore pH
  ignore strength
- volume (of acid)
- temperature (of acid)
  ignore room temperature

2

(c) (type of) metal / element

1

(d) (beryllium is) less reactive

1

any **one** from:

- greater attraction between nucleus and outer electrons
- more energy is needed to remove electrons
- loss of electrons is more difficult
- outer electrons closer to nucleus
- less shielding

1

allow converse answers for magnesium
MP2 only if MP1 is correct
allow higher in <u>group</u>
allow reactivity increases down the <u>group</u>
ignore reactivity series

(e) $\frac{50}{1000}$ (dm^3)

1

= 0.05 (dm^3)

1

($\frac{3.2}{0.05}$) 64 (g per dm^3)

1

alternative approach:

$\frac{3.2}{50}$ (1)

= 0.064 (1)

(× 1000) = 64 (g per dm^3) (1)

alternative approach:

$\frac{1000}{50}$ (1)

= 20 (1)

(× 3.2) = 64 (g per dm^3) (1)

*an answer of 64 (g per dm^3) scores **3** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

*an answer of 0.16 / 0.064 / 0.64 / 6.4 / 6.4×10^{-5} (g per dm3) gains **2** marks*

[9]

Q10.

(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]

Q11.

(a) potable

1

(b) boil (water)

ignore heat

*do **not** accept filter*

*do **not** accept incorrect test*

1

(boils) at 100°C

***alternative approach** freeze (water) (1)*

(freezes) at 0°C (1)

*if no other mark awarded, allow 1 mark for evaporate or distil water **and** no solid left*

1

*allow boils at 100°C for **2** marks*

(c) **Level 2:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

3−4

Level 1: The design/plan would not necessarily lead to a valid outcome. Some steps are identified, but the plan may not be logically sequenced.

1−2

No relevant content

0

Indicative content

- weigh container.
- measure volume (100 cm^3) of water into container.
- evaporate / heat until dry.
- weigh container and remaining solids.
- determine mass of dissolved solids

to access Level 2 there should be an indication of using a known volume of water, heating until dry and determining the mass of solid.

(d)

*an answer of 0.031 (g) scores **4** marks*

(conversion of cm^3 to dm^3)

(250 cm^3 =) $\frac{250}{1000}$ or 0.25 (dm^3)

1

(conversion of mg to g)

(125 mg =) $\frac{125}{1000}$ or 0.125 (g)

1

(0.25 × 0.125) = 0.03125

allow correct calculation from incorrect attempt(s) at conversion

1

=0.031 (g)

allow an answer correctly rounded to 2 significant figures from an incorrect calculation that uses the values in the question

1

(e) $\frac{44}{500} \times 100$

1

= 8.8 (%)

allow 9 (%)

1

an answer of 8.8 (%) or 9 (%) scores ***2*** *marks*

[13]

Q12.

(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]

Q13.

(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 → 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]

Q14.

(a) temperature (change)

1

(b) to reach a constant temperature

allow to reach room temperature

1

(c) line of best fit after 7 minutes

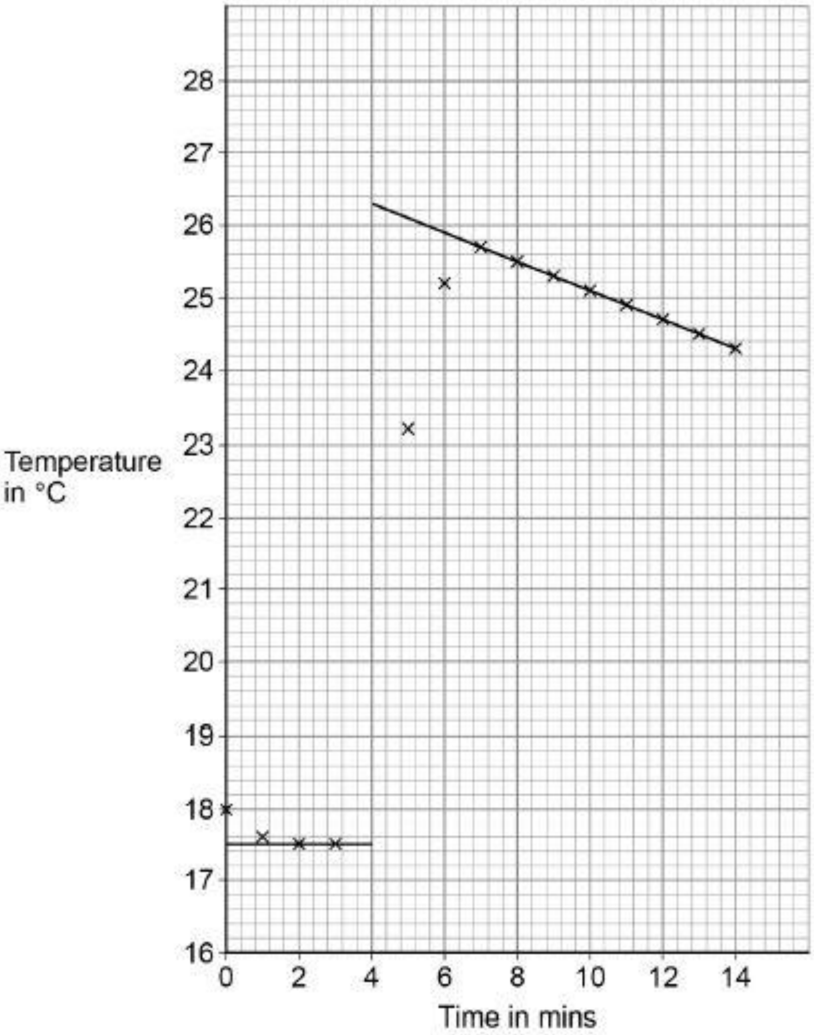
1

extends line back to 4 minutes

ignore extension of line beyond 4 minutes

1

the diagram below scores **2** marks



(d) (maximum **and** minimum values at 4 minutes)
26.3 (^{o}C) **and** 17.5 (^{o}C)

*allow ecf from **(c)***

1

(temperature change at 4 minutes)
= 8.8 (^{o}C)

1

(e) the reaction finished / stopped

allow maximum temperature has been reached

1

(so) energy is lost to surroundings / atmosphere
or
(so the) solution cools (back to room temperature)

allow heat for energy

1

(f) aluminium / zinc / iron / beryllium

allow Al / Zn / Fe / Be

*do **not** accept copper, silver*

MP2 dependent on a correct answer to MP1

1

metal **Q** is less reactive (than magnesium)
or
metal **Q** is lower in reactivity series

allow converse

1

(g) (unit conversion)
30.0 cm^3 = 0.030 dm^3
or
0.500 dm^3 = 500 cm^3

1

(moles = $\frac{30}{500}$ × 0.1 =) 0.006

allow correct use of incorrect / no unit conversion

or

(moles = $\frac{0.030}{0.50}$ × 0.1 =) 0.006

1

mass = 0.006 × 159.5

allow correct use of incorrect value for number of moles

1

= 0.957 (g)

allow 0.96 (g)

1

[14]

Q15.

(a) atoms have a positively charged nucleus.

1

mass is concentrated in the nucleus in the centre of atoms.

1

(b)

$$\frac{4 \times 10^{-7}}{2400}$$

1

$= 1.66666 \times 10^{-10}$

1

$= 1.67 \times 10^{-10}$ (m)

allow 0.000 000 000 167 (m)

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

1

(c) (moles Au = $\frac{0.175}{197}$ =) 0.000888

1

(moles Cl_2 = 0.000888 × $\frac{3}{2}$ =) 0.00133

allow a correct calculation using an incorrectly calculated value of moles of gold

1

(mass Cl_2 =) 0.00133 × 71

allow a correct calculation using an incorrectly calculated value of moles of chlorine

1

= 0.0946 (g)

1

= 94.6 (mg)

allow a correct conversion using an incorrectly calculated mass of chlorine

1

alternative approach:

(from equation 2 moles of Au reacts with 3 moles of Cl_2)
(so) 394 g Au reacts with 213 g Cl_2 (1)

1 g Au reacts with ($\frac{213}{394}$ =)
0.54 g Cl_2 (1)

allow a correct calculation using an incorrectly calculated value of mass of gold and / or chlorine

0.175 g Au reacts with
0.54 × 0.175 g Cl_2 (1)

allow a correct calculation using an incorrectly calculated value of mass of gold and / or chlorine

= 0.0946 (g) (1)

= 94.6 (mg) (1)

allow a correct conversion using an incorrectly calculated mass of chlorine

[10]

Q16.

(a) atomic weight

*do **not** accept atomic mass or A_r*

1

(b) left gaps / spaces

or

changed the order based on atomic weights

allow placed them in correct groups according to properties

*do **not** accept reference to atomic number*

1

(c) weak forces between the molecules
or
weak intermolecular forces

allow weak intermolecular bonds

*do **not** accept incorrect references to covalent bonds*

1

(so) little energy required to overcome / break the forces between molecules
or
(so) little energy required to overcome / break the intermolecular forces

allow (so) little energy required to separate the molecules

allow (so) little energy required to overcome / break the intermolecular bonds

ignore less energy

1

(d)

allow converse explanation in terms of boiling point

(the) molecules get larger going down the group

1

(so the) forces between the molecules increase
or
(so the) intermolecular forces increase

1

(so the) boiling points increase going down the group
or
(so the) boiling points increase with increasing relative atomic mass

allow (so) more energy is needed to separate the molecules

1

(e) 2,8

allow diagram or description

1

(so) stable arrangement of electrons
or
(so) full outer shell

1

(f)

*an answer of 1.51×10^{22} scores **2** marks*

$\frac{1}{40} \times 6.02 \times 10^{23}$

or

$0.025 \times 6.02 \times 10^{23}$

1

1.51×10^{22}

allow 1.505×10^{22}

1

[11]

Q17.

(a) glowing splint

1

relights

1

(b) equilibrium shifts to right-hand side

allow towards the products

allow in favour of the forward reaction

1

(because) concentration of SO_3 decreases

this marking point is dependent on first marking point being awarded

allow pressure decreases

allow to increase the concentration of SO_3 allow to re-establish equilibrium

1

(c) (M_r CaO =) 56

1

(M_r $CaSO_3$ =) 120

1

$\frac{7}{56} \times 120$

1

= 15(.0 g)

*an answer of 15(.0 g) scores **4** marks*

in all approaches allow a correct calculation using an incorrectly calculated M_r

alternative approach A

(M_r CaO =) 56 (1)

$\frac{7}{56}$ = 0.125 (moles) (1)

(mass $CaSO_3$ =) 0.125 × 120 (1)

= 15(.0 g) (1)

1

alternative approach B

M_r CaO =) 56 (1)

$\frac{56}{7}$ = 8 (factor) (1)

M_r $CaSO_3$ =) 120 (1)

$\frac{120}{8}$ = 15(.0 g) (1)

alternative approach C

M_r CaO =) 56 (1)

M_r $CaSO_3$ =) 120 (1)

$\frac{120}{56}$ *= 2.14235714 (factor)* (1)

2.14235714 × 7 = 15(.0 g) (1)

[8]

Q18.

(a) CaO

1

CO_2

1

either order
ignore names

(b) $[12 + (3 \times 16)]$
or 60

1

$(197 - 60 =)\ 137$

1

barium **or** Ba

*barium **or** Ba without working scores this mark*

1

*an answer of 137 scores the **2** calculation marks*

(c) (working) Y increase <u>and</u> X increase measured from graph and substitution into $\frac{\Delta Y}{\Delta X}$

y-axis	*80−85*	*162−170*	*248−252*	*330−335*
x-axis	*0.5*	*1.0*	*1.5*	*2.0*
=	*160−170*	*162−170*	*165−168*	*165−168*

1

(answer) 167

allow answer in range 160−174

1

(units) cm^3/g

allow $cm^3\ g^{-1}$

1

*if no other mark awarded allow **1** mark for the inverse (* $\frac{\Delta Y}{\Delta X}$ *)*
***or** 0.006*
*an answer of 160−174 scores the **2** calculation marks*

(d) (from graph)
volume to 240 cm^3 mass
= 1.45 g

allow answer based on any reading from the graph
(e.g. 250 cm^3 *= 1.5 g)*

1

ratio is $\frac{1}{100}$ (ie $\frac{24\,000}{240}$)

allow ratio from their volume

eg $\frac{24000}{250}$

1

100 × 1.45

$\left(\frac{24000}{250}\right) \times 1.5$

1

145

allow range 140−150

1

or

allow method using answer from part **(c)**

$x = \frac{y}{m}$ (1)

(rearrangement of y = mx where m = answer from part ***(c)****)*

24 (dm^3) to 24 000 (cm^3) (1)

$\frac{24000}{\text{answer from part } \textbf{(c)}}$ (1)

144 (1)

allow range 140−150

[12]

Q19.

(a) hydrogen **or** H_2

allow hydrogen gas
ignore H without the 2 subscript

1

(b) filtration / filter

*allow magnet **or** decant*
ignore heating

1

(c) (Mg) $\frac{0.12}{24}$ or 0.005 (moles)

mark is for ÷ by 24

1

(Fe) $\frac{2}{3} \times 0.005 = 0.00333 \times 56$

mark is for $\times \frac{2}{3}$

1

(mass Fe) = 0.00333 × 56

mark is for × 56

1

= 0.1866 (g)

1

= 187 (mg)

1

*an answer of 280 (mg) scores **4** marks*

*an answer of 0.280 scores **3** marks (no ratio from equation)*

*184 scores **0** [= (3 × 24) + (2 × 56)]*

OR

$(\text{Mg}) = \frac{0.12}{(3 \times 24 =)72}$ (1)

$= 0.00166$ **or** $\frac{1}{600}$ (moles) (1)

(mass of Fe) = 0.00166

or $\frac{1}{600} \times 112 (2 \times 56)$ (1)

= 0.1866 (g) (1)

187 (mg) (1)

OR

72 g Mg ⟶ 112g Fe (1)

$1 \text{ g Mg} \rightarrow \frac{112}{72}$ **or** 1.56 g Fe (1)

$0.12 \text{ g Mg} \rightarrow \frac{112}{72} \times 0.12$ (1)

= 0.1866 (g) (1)

= 187 (mg) (1)

*an answer of 185−190 (mg) scores **5** marks*

*an answer of 0.185−0.19 scores **4** marks*

(d) Fe^{3+}

1

(because) reduction is gain of electrons

allow change in oxidation state / (+)3 to 0

1

$Fe^{3+} + 3e^{(-)} \longrightarrow Fe$

1

[10]

Q20.

(a) $CaCl_2 + CO_2 + H_2O$

products in any order

1

balancing: **2** (HCl)

dependent on correct formulae for products

1

(b) value from graph used to show volume increase

must include a time or volume value

1

values from graph used to show the volume increases less rapidly

must include time interval or volume increment

1

volume **or** time stated when graph line levels off

*allow levels off at 60 (cm^3) **or** 28 to 30 s*
allow descriptions in terms of rate of reaction

1

values must be approximately correct

(c) draw tangent at <u>15 s</u>

allow draw a straight line on the curve at <u>15 s</u>

1

calculate gradient

allow correct description of gradient calculation
ignore calculations if given

1

(d) centimetres cubed per second

*allow cm^3/s **or** $cm^3\ s^{-1}$ (all lower case)*
allow mixture of abbreviations and words, e.g. centimetres cubed/s
*do **not** accept non-SI abbreviations (e.g. sec for s)*

1

(e) (rate) increases as chips get smaller

allow converse

1

(f) same amount of acid
or
same number of moles of acid

allow same volume of acid
allow same concentration of acid
allow same mass of $CaCO_3$ / marble chips
allow one reactant is the limiting factor

1

(g) (surface area of each face = 2 × 2 =) 4

1

(6 × 4 =) 24 (cm^2)

allow 6 × student's value from step 1

1

*an answer of 24 (cm^2) scores **2** marks*

(h) small(er) chips have large(r) surface area (for the same volume)

allow converse

1

so more frequent collisions

allow more chance of collisions
allow more likely to collide

*do **not** accept reference to speed of particles or energy of collisions*

ignore more collisions
ignore more successful collisions

1

(i) (sloping part is less steep because) reaction is slower

1

due to less frequent collisions

*do **not** accept reference to speed of particles or energy of collisions*
ignore fewer collisions

1

fewer acid particles (in same volume)

ignore weaker acid

1

or
(sloping part is less steep because) reaction is slower (1)

there are fewer acid particles (in same volume) (1)

(graph levels off lower) so less gas is produced (1)

allow converse for more concentrated acid

[17]

Q21.

(a) a mixture designed as a useful product **1**

(b) mass = 14 520 g **1**

$$(=)\frac{14\,520}{80\text{ (mol)}}$$

allow correct substitution of incorrectly converted mass
must use M_r given (80) to gain marks in steps 2 and 3 **1**

(=) 181.5 (mol) **1**

(=) 1.8×10^2 (mol)

allow answer correctly given in standard form to correct sig figs from an incorrect calculation **1**

*an answer of 1.8×10^2 (mol) gains **4** marks*

(c) (giant) lattice

allow giant structure **1**

ionic **1**

strong bonds **or** strong electrostatic forces

*do **not** accept strong intermolecular forces / bonds* **1**

large amounts of energy needed to overcome

ignore heat **1**

***max 2 marks** for incorrect reference to bonding **or** structure **or** particles*

[9]