Do not write outside the box

0 1 Soluble salts are formed by reacting metal oxides with acids.

0 1 . 1 Give **one** other type of substance that can react with an acid to form a soluble salt.

[1 mark]

0 1 . 2 Calcium nitrate contains the ions Ca^{2+} and NO_3^-

Give the formula of calcium nitrate.

[1 mark]

0 1 . 3 Describe a method to make pure, dry crystals of magnesium sulfate from a metal oxide and a dilute acid.

[6 marks]

Do not write outside the box

0 5 A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

Table 2 shows the student's results.

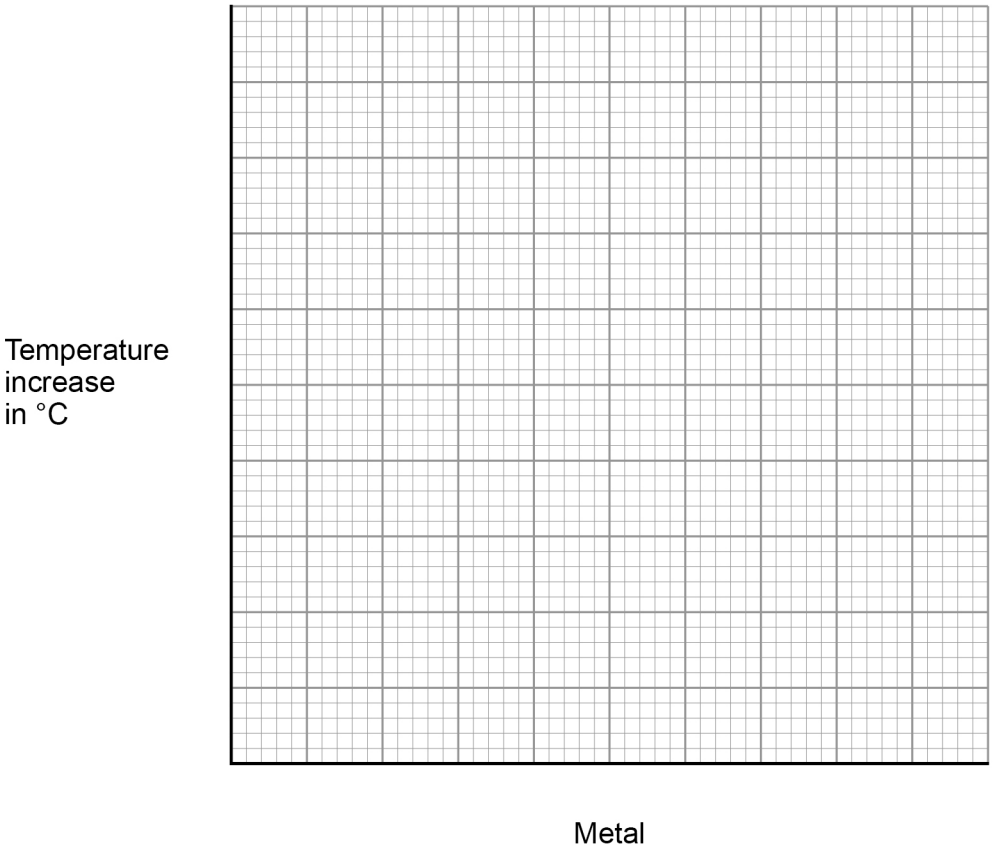
Table 2

Metal	Temperature increase in °C
Copper	0
Iron	13
Magnesium	43
Zinc	17

0 5 . 1 Plot the data from **Table 2** on **Figure 4** as a bar chart.

[2 marks]

Figure 4



Do not write outside the box

0 5 . 2 The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

[1 mark]

0 5 . 3 The temperature change depends on the reactivity of the metal.

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

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

Your method should give valid results.

[4 marks]

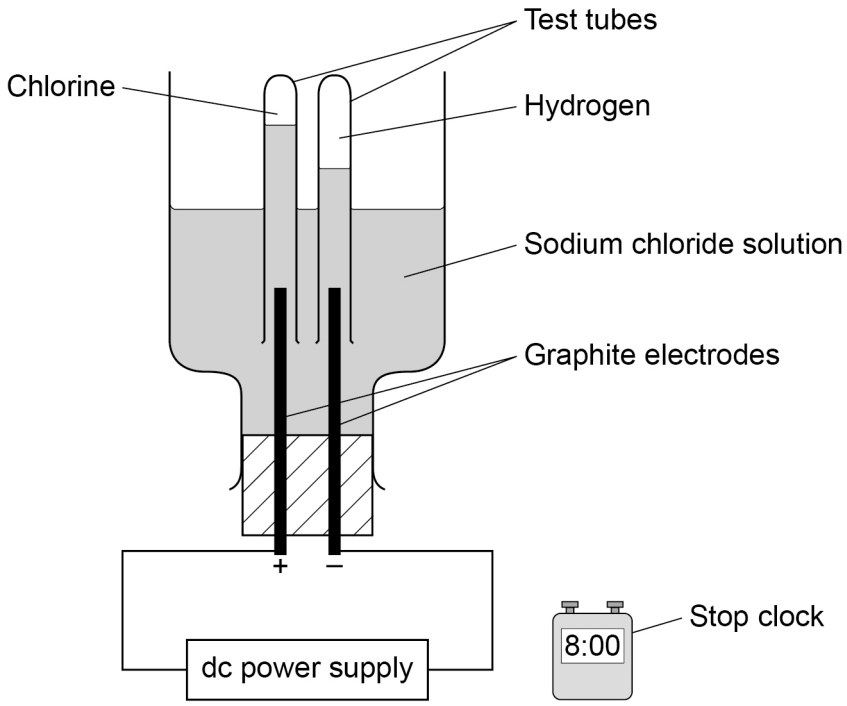
Question 5 continues on the next page

Do not write outside the box

The student investigated how the volume of gases produced changes with time in the electrolysis of sodium chloride solution.

Figure 7 shows the apparatus.

Figure 7



0 6 . 3 The student made an error in selecting the apparatus for this investigation.

How should the apparatus be changed?

Give **one** reason for your answer.

[2 marks]

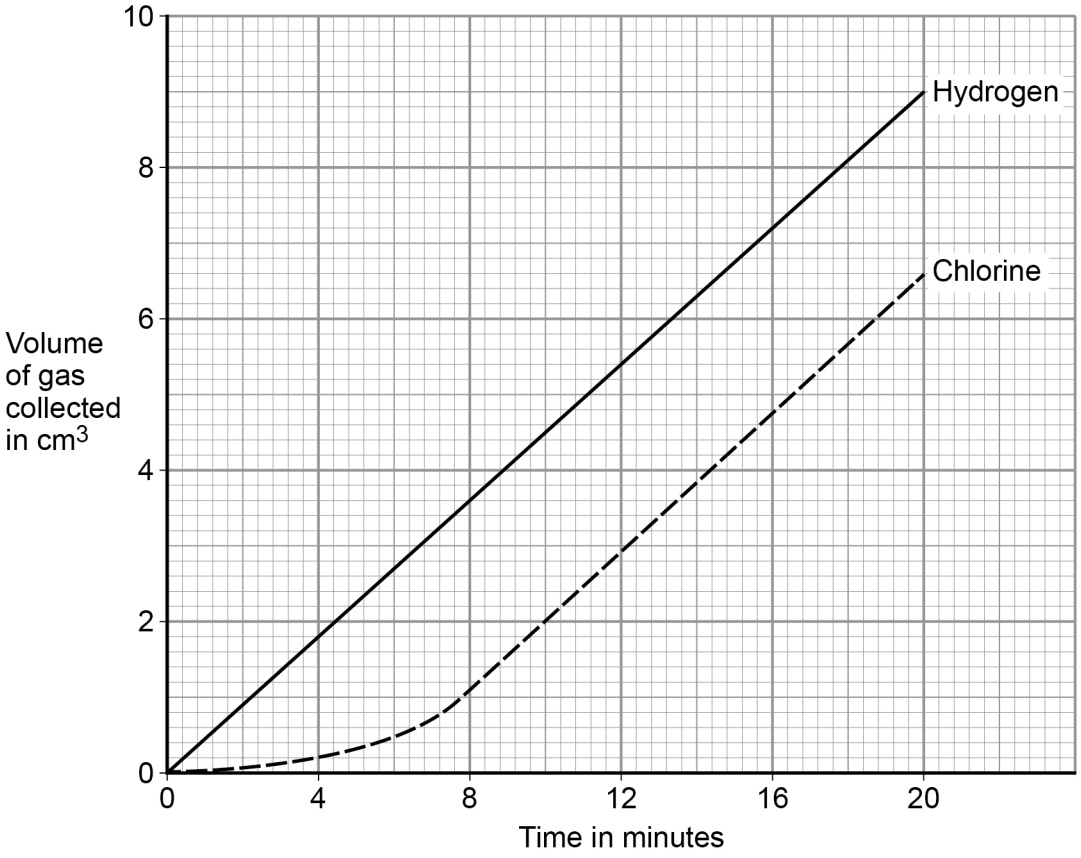
Do not write outside the box

Another student used the correct apparatus.

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

Figure 8 shows the student's results.

Figure 8



0 6 . 4 Describe the trends shown in the results.

Use values from **Figure 8**.

[3 marks]

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **one** from: • metal • (metal) hydroxide • (metal) carbonate • alkali	allow named example allow correct formula ignore base allow ammonium hydroxide allow ammonium carbonate allow soluble base allow ammonia	1	AO1 4.4.2.1 4.4.2.2 4.4.2.3
01.2	$Ca(NO_3)_2$	allow $Ca^{2+}(NO_3^-)_2$	1	AO2 4.4.2.2

Question	Answers	Mark	AO / Spec. Ref.
01.3	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.	5–6	AO1 4.4.2.3
	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 • use magnesium oxide and sulfuric acid • add sulfuric acid to a beaker • warm sulfuric acid • add magnesium oxide • stir • continue adding until magnesium oxide is in excess • filter • using a filter paper and funnel • to remove excess magnesium oxide • heat solution in an evaporating basin • to crystallisation point • leave to crystallise • pat dry with filter paper credit may be given for diagrams		
Total		**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	all 4 metals labelled and suitable scale on *y*-axis	magnesium value must be at least half the height of the grid	1	AO2 4.4.1.2 4.5.1.1
	all bars correctly plotted	allow a tolerance of ± ½ a small square ignore width and spacing of bars allow **1** mark if copper not included and other 3 bars plotted correctly	1	
05.2		ignore because it is exothermic ignore references to copper		AO3 4.5.1.1
	temperature increases	allow (because) energy / 'heat' is transferred to the surroundings allow energy / 'heat' is given out	1	
	or			
	temperature does not decrease	allow energy / 'heat' is not taken in (from the surroundings) allow the energy of the products is less than the energy of the reactants		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	suitable method described		1	AO3 4.4.1.2
	the observations / measurements required to place in order	dependent on a suitable method	1	4.5.1.1
	an indication of how results would be used to place the unknown metal in the reactivity series		1	
	a control variable to give a valid result		1	
	approaches that could be used **approach 1:** add the unknown metal to copper sulfate solution (1) measure temperature change (1) place the metals in order of temperature change (1) any **one** from (1): • same volume of solution • same concentration of solution • same mass / moles of metal • same state of division of metal **approach 2:** add the metal to salt solutions of the other metals **or** heat the metal with oxides of the other metals (1) measure temperature change (only if salt solutions used) **or** observe whether a chemical change occurs (1) place the metals in order of temperature change **or** compare whether there is a reaction to place in correct order (1) any **one** from (1): • same volume of salt solutions • same concentration of salt solutions • same (initial) temperature of salt solutions • same mass / moles of metal **or** metal oxide • same state of division of metal **or** metal oxide			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3 cont.	**approach 3:** add all of the metals to an acid (1) measure temperature change or means of comparing rate of reaction (1) place the metals in order of temperature change or rate of reaction (1) any **one** from (1): • same volume of acid • same concentration of acid • same (initial) temperature of acid • same mass / moles of metal • same state of division of metal **approach 4:** set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1) measure the voltage of the cell (1) place the metals in order of voltage (1) any **one** from (1): • same electrolyte • same concentration of electrolyte • same temperature of electrolyte			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	solid (zinc chloride) does not conduct (electricity) **or** zinc chloride needs to be in solution **or** molten	allow liquid / aqueous	1	AO1 4.4.3.1
	(because) ions cannot move in the solid **or** (as) ions can (only) move in liquid / solution	do **not** accept references to movement of electrons in zinc chloride	1	
06.2		allow free electrons for delocalised electrons		AO1 4.2.3.2
	each carbon / atom forms 3 (covalent) bonds		1	
	one electron per carbon / atom is delocalised		1	
	(so) these electrons carry charge through the graphite **or** (so) these electrons move through the structure	ignore carry current / electricity	1	
		if no other mark scored, allow **1** mark for delocalised / free electrons		
06.3	use measuring cylinders (instead of test tubes)	allow use burettes allow use (gas) syringes allow Hoffmann voltameter	1	AO3 4.4.3.4
	(because) test tubes cannot measure volume **or** (because) test tubes have no graduations / scale	allow (so that) volume can be measured	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	any **three** from: • the volume of hydrogen collected is directly proportional to the time • the rate of collection of hydrogen is 0.45 (cm^3/min) • up to 8 minutes chlorine is collected at an increasing rate • after 8 minutes the rate of collection of chlorine is the same as that of hydrogen **or** after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)	allow the (volume of) hydrogen is collected at a constant / steady rate allow any value from 6 to 8 minutes allow initially chlorine is collected at an increasing rate allow any value from 6 to 8 minutes allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate if neither bullet point 3 nor bullet point 4 is awarded allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly allow any value from 6 to 8 minutes	3	AO2 4.4.3.4
06.5	chlorine reacts with water **or** chlorine dissolves (in the solution)		1	AO3 4.3.5 4.4.3.4

Do not write outside the box

0 4 A student investigated the colours in three different flowers, **A**, **B** and **C**.

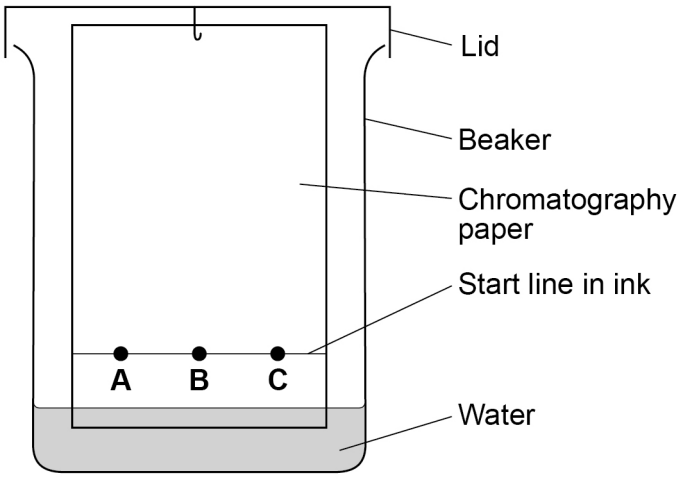
The colours are soluble in ethanol but are insoluble in water.

This is the method used.

1. Crush flower **A**.
2. Add ethanol to flower **A**.
3. Filter the mixture.
4. Put spots of the coloured filtrate on to the chromatography paper.
5. Repeat steps 1-4 with flowers **B** and **C**.

Figure 4 shows the apparatus used.

Figure 4



0 4 . 1 The student made **two** mistakes in setting up the apparatus.

Give **one** problem caused by each mistake.

[4 marks]

Mistake 1 _____

Problem caused _____

_____

Mistake 2 _____

Problem caused _____

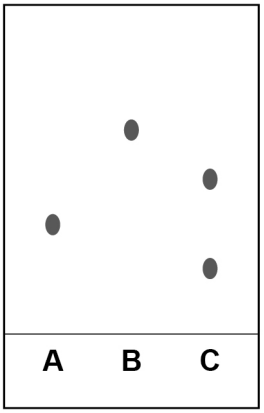
_____

Do not write outside the box

0 4 . 2 Another student set up the apparatus correctly.

Figure 5 represents the student's results.

Figure 5



Give **two** conclusions you can make from **Figure 5**.

[2 marks]

1 _____

_____

2 _____

_____

0 4 . 3 Colour **A** has an R_f value of 0.65

Colour **A** moves 3.2 cm

Calculate the distance moved by the solvent.

[2 marks]

_____

_____

Distance moved by solvent = _____ cm

8

Turn over ►

Do not write outside the box

0 5 Sodium thiosulfate solution reacts with dilute hydrochloric acid.

The solution becomes cloudy as the reaction takes place.

0 5 . 1 The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + SO_2(g) + H_2O(l) + S(s)$$

Explain why the solution becomes cloudy.

[2 marks]

0 5 . 2 Plan an investigation to show how the concentration of the sodium thiosulfate solution affects the rate of the reaction with dilute hydrochloric acid.

Your plan should give valid results.

[6 marks]

Do not write outside the box

8

Turn over for the next question

Do not write outside the box

0 8 A student investigated how temperature affects the rate of reaction between magnesium carbonate and dilute hydrochloric acid.

This is the method used.

1. Heat hydrochloric acid to 30 ºC in a conical flask.
2. Add magnesium carbonate powder to the conical flask.
3. Measure the loss in mass of the flask and contents every 20 seconds for 140 seconds.
4. Repeat steps 1-3 with hydrochloric acid heated to 50 ºC

0 8 . 1 Explain why the contents of the conical flask lose mass.

[2 marks]

0 8 . 2 **Table 5** shows the student's results for hydrochloric acid at 30 ºC

Table 5

Time in seconds	Loss of mass in grams
0	0.00
20	0.26
40	0.48
60	0.67
80	0.82
100	0.91
120	0.96
140	0.99

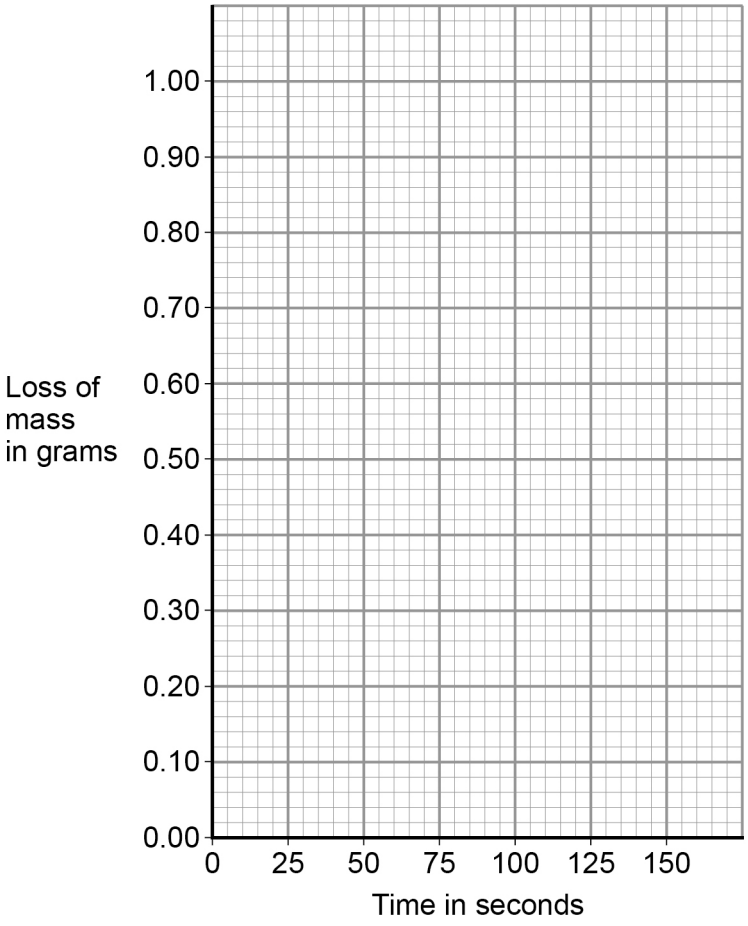
Do not write outside the box

Plot the data from **Table 5** on **Figure 6**.

Draw a line of best fit.

[3 marks]

Figure 6

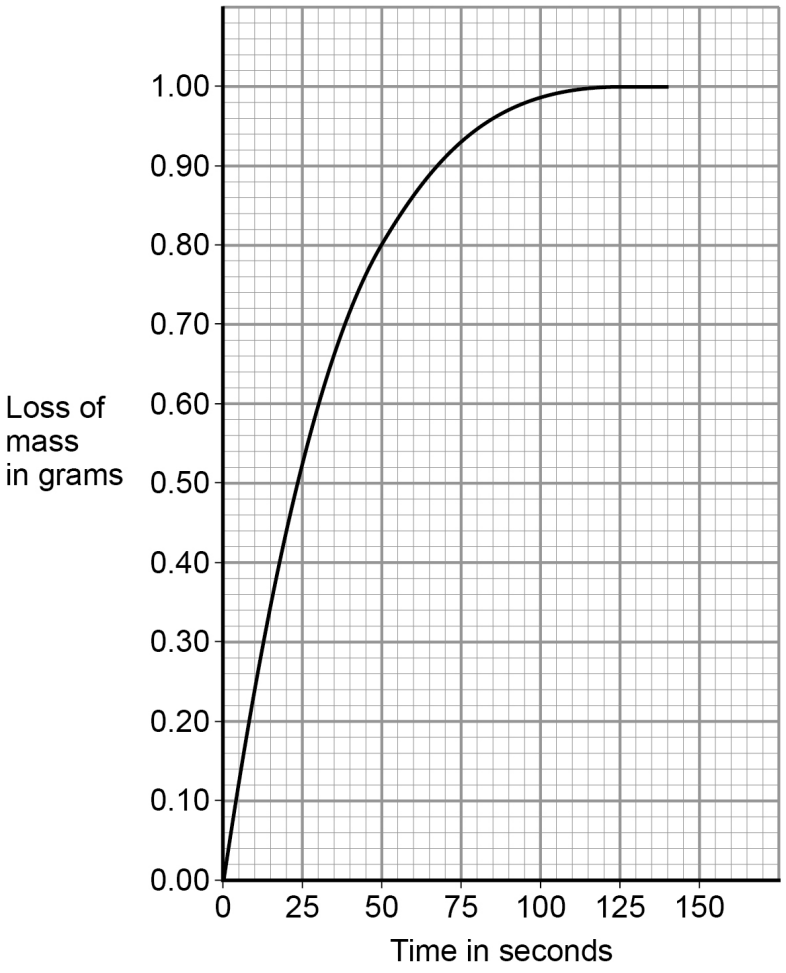


Question 8 continues on the next page

Do not write outside the box

Figure 7 shows the student's results for hydrochloric acid at 50 ºC

Figure 7



0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

Rate of reaction = _____ g/s

9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	start line drawn in ink	allow start line should have been drawn in pencil	1	AO3 4.8.1.3
	(so) ink dissolves **or** ink runs in solvent / water	(as) pencil does not dissolve **or** pencil does not run in solvent / water	1	
	water used (as solvent) **or** water in beaker	allow ethanol not used	1	
	(so) colours will not dissolve / move		1	
04.2	any **two** from: • the flowers have no colours in common	allow the flowers are not the same colour	2	AO3 4.8.1.3
	• A / B contain one colour			
	• C contains two colours	allow C is a mixture of colours		
	• (the colour in) B is most soluble	allow (the colour in) B has the highest R_f value allow one of the colours in C is the least soluble		
04.3		an answer of 4.9 (cm) scores **2** marks		AO2 4.8.1.3
	(distance moved =) $\frac{3.2}{0.65}$		1	
	(distance moved) = 4.9 (cm)	allow 4.923076923 (cm) correctly rounded	1	
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	sulfur (formed) (which is a) precipitate	allow S / S_8 (formed) allow (which is a) solid allow (which is) insoluble	1 1	AO2 4.2.2.2
05.2	**Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.		5–6	AO1 4.6.1.2
	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 **method** • measure (indicated) volume of sodium thiosulfate • place sodium thiosulfate in (conical) flask • measure (indicated) volume of hydrochloric acid • place on cross **or** between light sensor **or** connect to a gas syringe **or** other suitable method for timing a change • add hydrochloric acid to (conical) flask • swirl • start stopclock / stopwatch • measure time for cross to become no longer visible **or** log light transmission over time **or** measure time for fixed volume of gas to be produced • repeat and find mean • repeat for different concentrations of sodium thiosulfate **or** change ratio of sodium thiosulfate volume : water volume **control variables** • concentration of hydrochloric acid • volume of hydrochloric acid • (total) volume of sodium thiosulfate solution			
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	a gas is produced	allow carbon dioxide is produced do **not** accept an incorrect gas	1	AO2 4.3.1.3 4.6.1.1
	(which) escapes	**max 1** mark if evaporation mentioned	1	
08.2	all eight points plotted correctly	allow a tolerance of ± half a small square. allow six or seven points plotted correctly for **1** mark	2	AO2 4.6.1.1
	line of best fit		1	
08.3		an incorrect answer for one step does not prevent allocation of marks for subsequent steps		AO2 4.6.1.1
	correctly drawn tangent at 0.95 g		1	
	correct value for x step **and** y step from tangent	allow evidence of use of two points on tangent either on the graph or in the text	1	
	(rate =) $\frac{\text{value for y step}}{\text{value for x step}}$		1	
	correctly evaluated and rounded to 2 sig figs	allow (rate =) $\frac{\text{value for x step}}{\text{value for y step}}$ (ie inverted division) correctly evaluated and rounded to 2 sig figs	1	
Total			**9**	

0 3 **Figure 2** shows four test tubes a student set up to investigate the rusting of iron.

This is the method used for each test tube.

1. Measure the mass of the nail using a balance.
2. Leave the nail in the test tube for 6 days.
3. Measure the mass of the nail after 6 days.

Figure 2

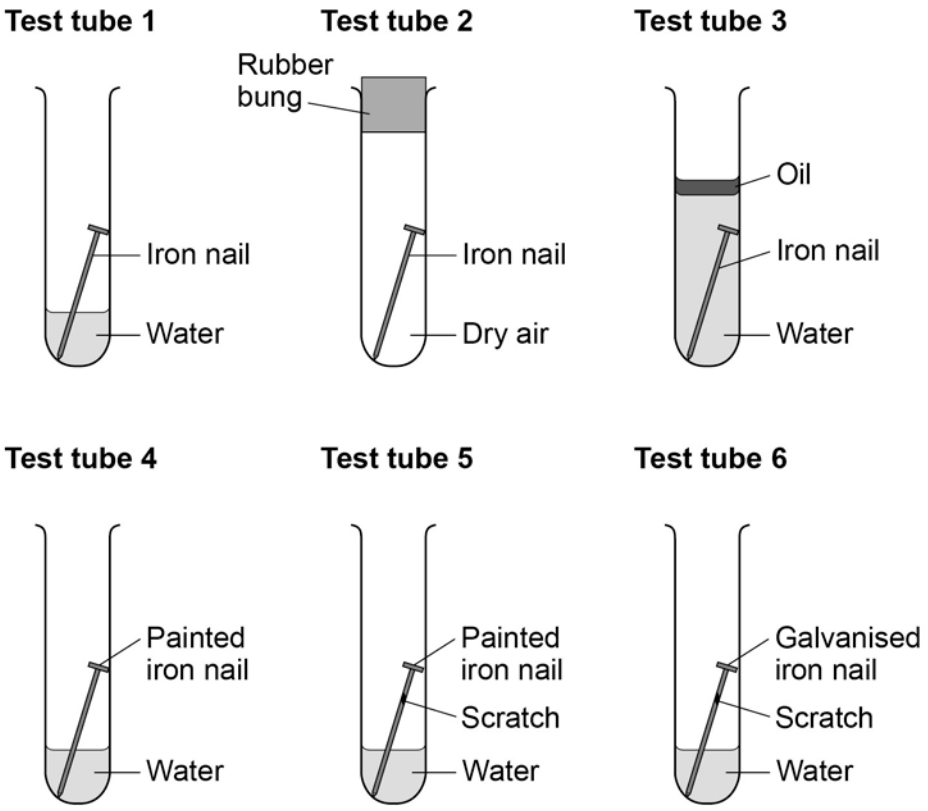


Table 2 shows the student's measurements.

Table 2

Test tube	Mass of nail in g	Mass of nail after 6 days in g
1	8.45	8.91
2	8.46	8.46
3	8.51	8.51
4	9.65	9.65
5	9.37	9.45
6	9.79	9.79

0 3 . 1 What is the resolution of the balance the student used?

[1 mark]

Tick **one** box.

1×10^{-3} g ☐

1×10^{-2} g ☐

1×10^{-1} g ☐

1×10^{2} g ☐

Question 3 continues on the next page

0 3 . 2 Calculate the difference in percentage increase in mass after 6 days of the nail in test tube **1** and the nail in test tube **5**.

Give your answer to **three** significant figures.

[4 marks]

Difference in percentage increase in mass = _____ %

0 3 . 3 Use the results of the student's investigations to draw conclusions about the factors affecting the rusting of iron. Include an evaluation of the effectiveness of different coatings at preventing the rusting of iron.

[6 marks]

0 3 . 4 Rust is hydrated iron(III) oxide.

Complete the word equation for the reaction.

[2 marks]

_____ + _____ + _____ → hydrated iron(III) oxide

Turn over for the next question

0 4 Rock salt is a mixture of sand and salt.

Salt dissolves in water. Sand does **not** dissolve in water.

Some students separated rock salt.

This is the method used.

1. Place the rock salt in a beaker.
2. Add 100 cm^3 of cold water.
3. Allow the sand to settle to the bottom of the beaker.
4. Carefully pour the salty water into an evaporating dish.
5. Heat the contents of the evaporating dish with a Bunsen burner until salt crystals start to form.

0 4 . 1 Suggest **one** improvement to step 2 to make sure all the salt is dissolved in the water.

[1 mark]

0 4 . 2 The salty water in step 4 still contained very small grains of sand.

Suggest **one** improvement to step 4 to remove all the sand.

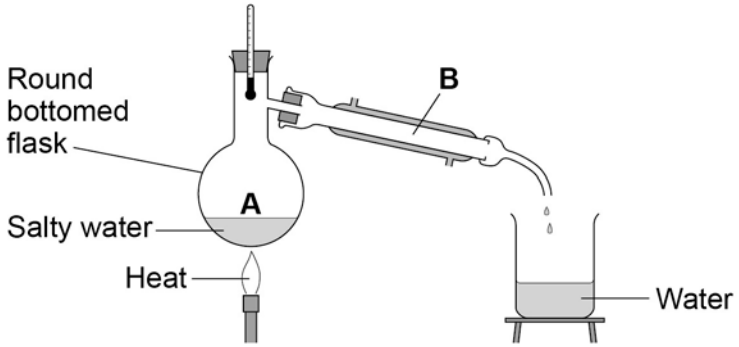
[1 mark]

0 4 . 3 Suggest **one** safety precaution the students should take in step 5.

[1 mark]

Another student removed water from salty water using the apparatus in **Figure 3**.

Figure 3



0 4 . 4 Describe how this technique works by referring to the processes at **A** and **B**.

[2 marks]

0 4 . 5 What is the reading on the thermometer during this process?

[1 mark]

_____ °C

0 5 A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

0 5 . 1 Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

[4 marks]

0 7 Sodium carbonate reacts with dilute hydrochloric acid:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

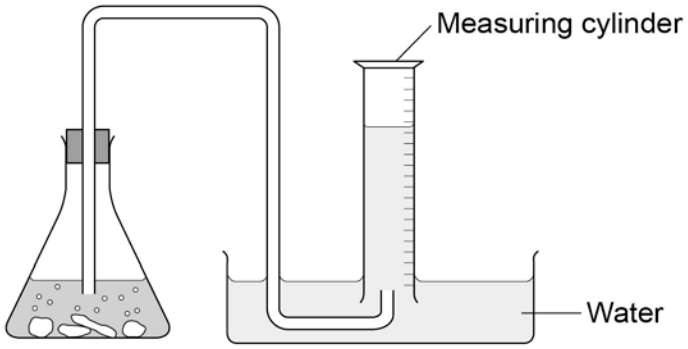
A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

0 7 . 1 The student set up the apparatus as shown in **Figure 5**.

Figure 5



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

[2 marks]

The student corrected the error.

The student's results are shown in **Table 4**.

Table 4

Mass of sodium carbonate in g	Volume of carbon dioxide gas in cm^3
0.07	16.0
0.12	27.5
0.23	52.0
0.29	12.5
0.34	77.0
0.54	95.0
0.59	95.0
0.65	95.0

0 7 . 2 The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

[1 mark]

0 7 . 3 Why does the volume of carbon dioxide collected stop increasing at 95.0 cm^3?

[1 mark]

Question 7 continues on the next page

0 7 . 4 What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm^3 of carbon dioxide?

[1 mark]

0 7 . 5 The carbon dioxide was collected at room temperature and pressure.
The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3.

How many moles of carbon dioxide is 95.0 cm^3?

Give your answer in three significant figures.

[2 marks]

_____ mol

0 7 . 6 Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

[2 marks]

0 7 . 7 One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

[2 marks]

Turn over for the next question

0 8 Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

0 8 . 1 Sulfuric acid is a strong acid.

What is meant by a strong acid?

[2 marks]

0 8 . 2 Write the ionic equation for this neutralisation reaction. Include state symbols.

[2 marks]

A student used a pipette to add 25.0 cm^3 of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol/dm^3 sulfuric acid needed to neutralise the sodium hydroxide.

0 8 . 3 Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen.

[4 marks]

Question 8 continues on the next page