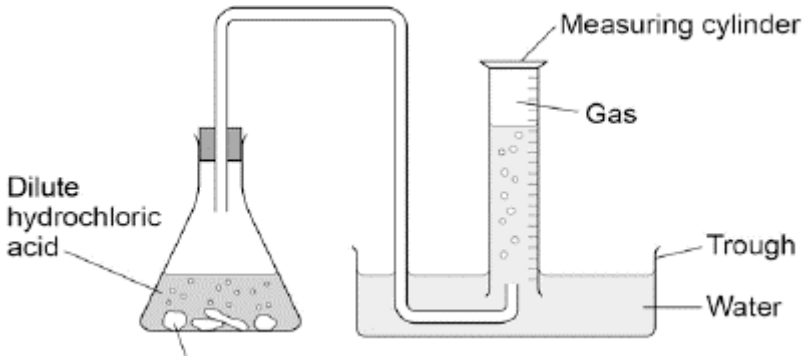
4-4 Chemical changes – Chemistry

1.0 A student investigated the reaction of sodium carbonate with dilute hydrochloric acid. The student used the apparatus shown in **Figure 1**.

Figure 1



This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 15 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 as shown in **Figure 1**.

1.1 Balance the equation for the reaction.

[1 mark]

Na_2CO_3 (s) + _____ HCl (aq) → _____ NaCl (aq) + H_2O (l) + CO_2 (g)

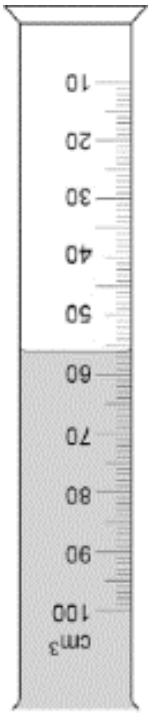
1.2 Name the substance produced as a gas.

[1 mark]

_____

Figure 2 shows the measuring cylinder.

Figure 2



1.3 What volume of gas has been collected?

[1 mark]

Volume = _____ cm^3

1.4 **Table 1** shows the student's results.

Table 1

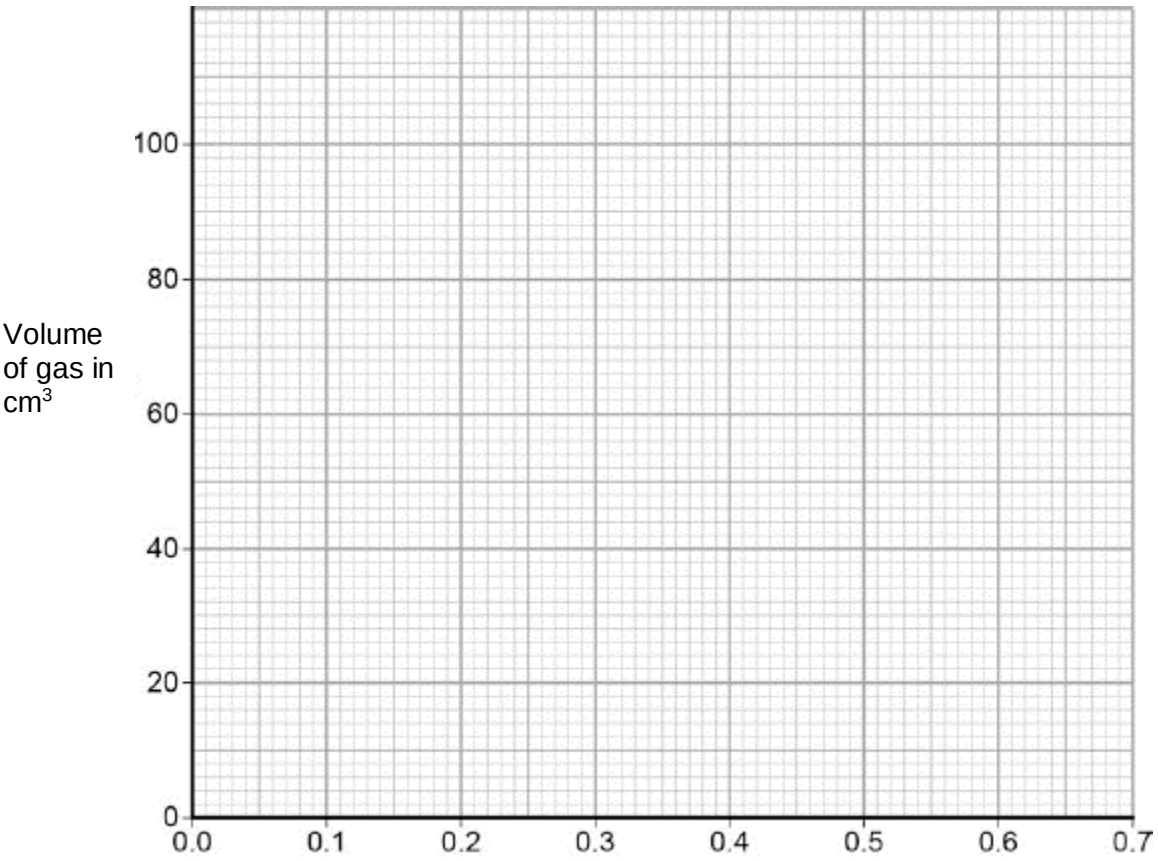
Mass of sodium carbonate in g	Volume of gas in cm^3
0.0	0
0.1	23
0.2	28
0.3	69
0.4	92
0.5	98
0.6	98
0.7	98

On **Figure 3**:

- Plot these results on the grid.
- Complete the graph by drawing **two** straight lines of best fit.

[4 marks]

Figure 3



1.5 Describe **two** patterns the graph shows when sodium carbonate is added.

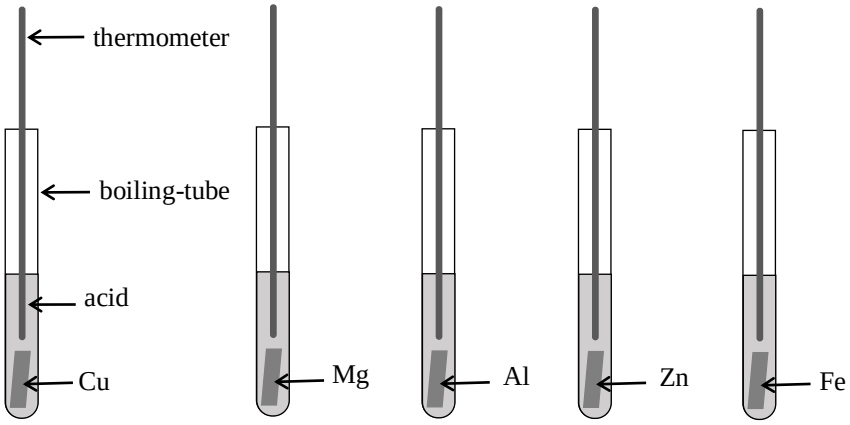
[2 marks]

2.0 Describe a safe method for making pure crystals of magnesium chloride from magnesium carbonate and dilute hydrochloric acid.
In your method you should name all of the apparatus you will use.

[6 marks]

3.0 A student investigated the reactivity of metals with acids.
Five different metals were investigated.
Figure 4 shows the apparatus the student used.

Figure 4



The method the student used was:

- measured 10 cm^3 of dilute acid using a 50 cm^3 measuring cylinder
- placed 10 cm^3 of dilute acid in a boiling tube
- added a 2 cm length of metal to the dilute acid
- measured the highest temperature reached
- repeated the experiment using different metals.

Table 1 shows the student's results.

Table 1

Metal	Temperature change (°C)			
	Test 1	Test 2	Test 3	Mean
Aluminium	33	10	35	
Copper	1	0	2	1
Iron	22	21	20	21
Magnesium	44	46	45	45
Zinc	25	27	26	26

3.1 State the dependent and independent variables in the investigation.

[2 marks]

Dependent variable_____

Independent variable _____

3.2 Name **two** control variables the student kept the same.

[2 marks]

_____

_____

3.3 Calculate the mean temperature change for aluminium.

[1 mark]

Mean temperature change for aluminium = _____ °C

3.4 Suggest **two** changes that could improve the accuracy of the investigation.

[2 marks]

_____

_____

3.5 Use the data in **Table 1** to list the metals in order of reactivity from most reactive to least reactive.

[1 mark]

_____

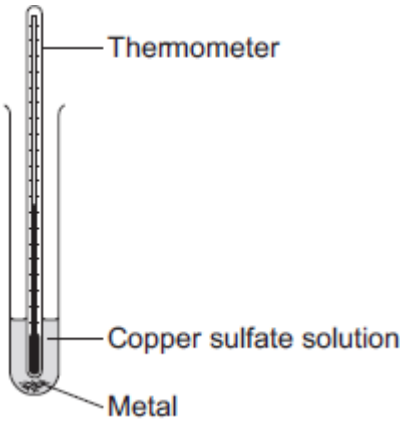
3.6 Suggest why the student did not use any Group 1 metals in the investigation.

[1 mark]

_____

4.0 A student investigated displacement reactions of metals.
The student added different metals to copper sulfate solution and measured the temperature change.
The more reactive the metal is compared with copper, the bigger the temperature change.
The apparatus the student used is shown in **Figure 5.**

Figure 5



The student repeated the experiment three times with each metal.
Table 2 shows the mean temperature change for each metal.

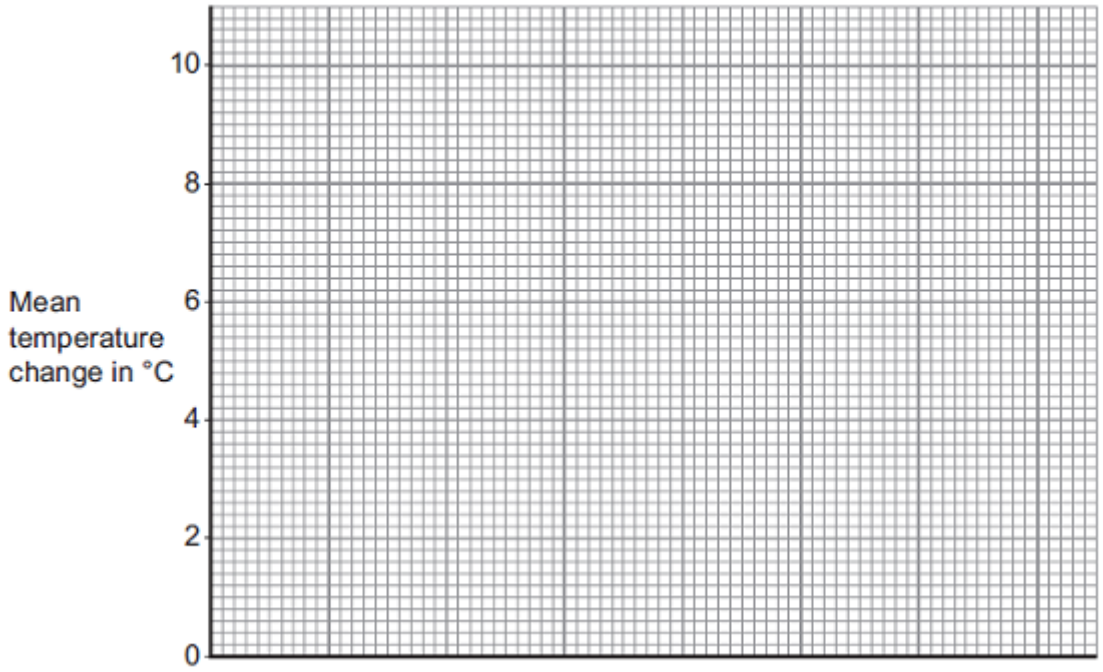
Table 2

Metal	**Mean temperature change in °C**
Copper	0.0
Iron	6.5
Lead	1.2
Magnesium	10.0
Silver	0.0
Zinc	7.8

4.1 On **Figure 6**, draw a bar chart to show the results.

[3 marks]

Figure 6



4.2 Why is a bar chart the most suitable way of showing the results?

[1 mark]

_____

4.3 Explain how these results can be used to work out a reactivity series.

[1 mark]

_____

4.4 Iron can be extracted by reacting iron oxide with carbon in a blast furnace.
What type of reaction produces iron from iron oxide?

[1 mark]

_____

5.0 Magnesium is extracted by the electrolysis of molten magnesium chloride**.**

5.1 Complete the half equation for the formation of magnesium at the negative electrode.

[2 marks]

Mg^{2+} + →

5.2 Chlorine gas is also produced.
Describe how chlorine is produced during the process.

[4 marks]

5.3 Some metals are extracted from their ores using carbon.
Why is it not possible to extract magnesium using carbon?

[1 mark]

5.4 Aqueous magnesium chloride is not used to extract magnesium.
Explain why.

[3 marks]

6.0 Bath bombs contain solid citric acid and solid sodium hydrogen carbonate.

6.1 Citric acid reacts with sodium hydrogen carbonate to produce a salt, sodium citrate.
The equation for the reaction is:

$$H_3C_6H_8O_7\,(s) + 3NaHCO_3\,(s) \rightarrow Na_3C_6H_8O_7\,(aq) + 3CO_2\,(g) + 3H_2O\,(l)$$

Which part of the equation shows that this reaction only takes place when bath bombs are added to water?

[1 mark]

_____

6.2 Bath bombs fizz when added to water.
What causes the fizzing?

[2 marks]

_____

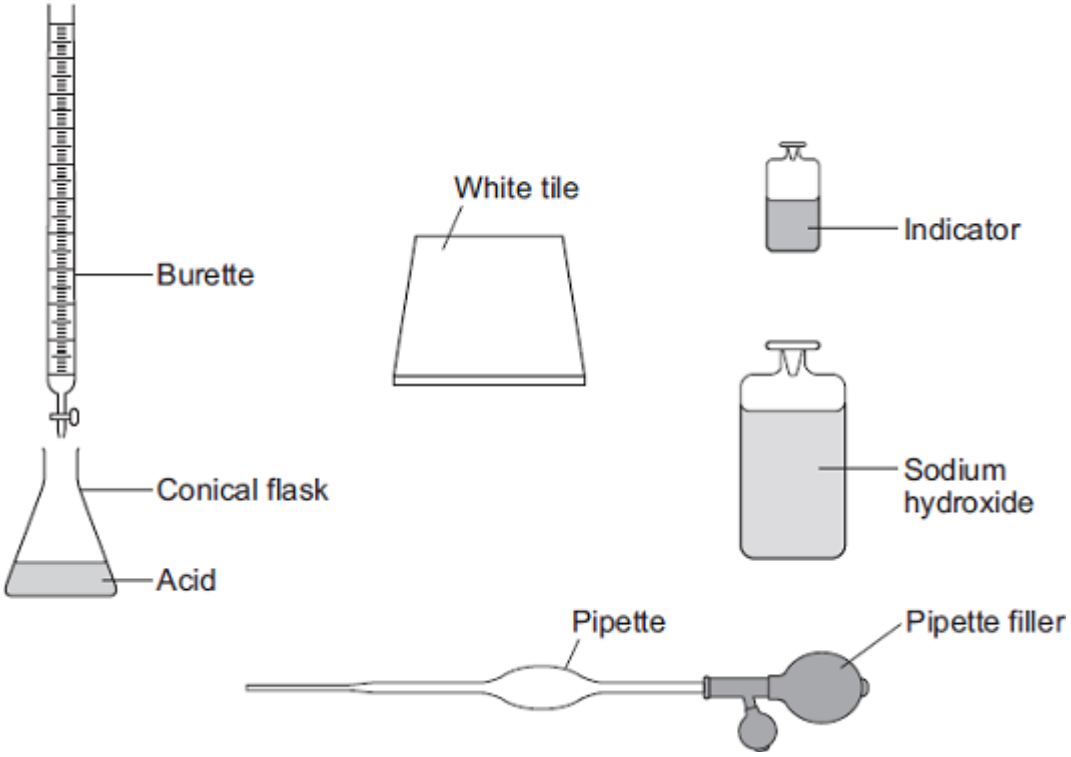
_____

6.3 Citric acid is a weak acid.
State what is meant by the term weak acid.

[1 mark]

_____

7.0 A student used the equipment shown to do a titration.



7.1 Describe how the student should use this equipment to find the volume of sodium hydroxide solution that reacts with 25 cm^3 of nitric acid.
Include:

- Which indicator would be suitable for use
- The colour change seen
- Any measurements the student should make
- How the results should be processed.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	Na_2CO_3 (s) + 2 HCl (aq) → 2NaCl (aq) + H_2O (l) + CO_2 (g)		1
1.2	Carbon dioxide		1
1.3	56 (cm^3)		1
1.4	All points correct 2 best fit lines drawn	± ½ small square allow **1** mark if 6 or 7 of the points are correct must not deviate towards anomalous point allow **1** mark if 1 line correct	2 2
1.5	Any **two** from: • As mass of lithium carbonate increases volume of gas produced increases • No more gas is produced after 0.5 g of sodium carbonate is added • Until 0.4 g of sodium carbonate is added the graph is linear / (directly) proportional		2

Qu No.		Extra Information	Marks
2.0			
Level 3:	A coherent method is described with relevant detail, and in correct sequence which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered. The method would lead to the production of valid results.		5-6
Level 2:	The bulk of the method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.		3-4
Level 1:	Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.		1-2
Level 0:	No relevant content		0
Indicative content			
• Hydrochloric acid in beaker (or similar) • Add magnesium carbonate one spatula at a time • Until magnesium carbonate is in excess or until no more effervescence occurs • Filter using filter paper and funnel • Filter excess magnesium carbonate • Pour solution into evaporating basin / dish • Heat using Bunsen burner • Leave to crystallise / leave for water to evaporate / boil off water • Decant solution • Pat dry (using filter paper) • Wear safety spectacles / goggles			

Qu No.		Extra Information	Marks
3.1	Dependent variable Temperature change Independent variable Type of metal		1 1
3.2	Any **two** from: • Concentration of acid • Volume of acid • Type of acid • Mass of metal • Size of metal • Surface area of metal		2
3.3	34 (°C)		1
3.4	Any **two** from: • Measure the mass of the metal (instead of length) • Use a thermometer that reads to more decimal places/ has more scale divisions. • Use a burette or pipette to measure volume of acid • Use a 10 cm^3 measuring cylinder (instead of 50 cm^3) • Use a measuring cylinder with more scale divisions	Allow use a digital thermometer that reads to more decimal places	2
3.5	Most reactive Magnesium Aluminium Zinc Iron Copper	Allow ecf from calculation of mean	1
3.6	They would be too reactive/dangerous		1

Qu No.		Extra Information	Marks
4.1	Four bars of correct height Bars labelled	tolerance is ± half square allow 3 bars correct for **1** mark	2 1
4.2	One variable is non-continuous / categoric	allow qualitative or discrete allow no values between the metals	1
4.3	Most reactive metal has the highest temperature change		1
4.4	Reduction		1

Qu No.		Extra Information	Marks
5.1	$Mg^{2+} + 2e^- \rightarrow Mg$	Allow **1** mark for e^-	2
5.2	Chloride ions attracted to positive electrode (where they) lose electrons chlorine atom / molecule produced		1 1 1 1
5.3	Magnesium too reactive or Carbon not reactive enough		1
5.4	Magnesium ions and hydrogen ions attracted to negative electrode Hydrogen is formed in preference to magnesium As hydrogen less reactive (than magnesium)		1 1 1

Qu No.		Extra Information	Marks
6.1	(aq) Means aqueous solution		1
6.2	Carbon dioxide produced Which is released as a gas	For **2** marks, allow carbon dioxide gas is produced	1 1
6.3	Does not fully ionise/dissociate	Allow only partially ionises/dissociates	1

Qu No.		Extra Information	Marks
7.1			
Level 3:	A full, coherent description of a titration that would allow successful results to be obtained. No major errors in science or in naming equipment or chemicals.		5-6
Level 2:	The bulk of the titration is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail. There may be some minor errors in science or in naming equipment or chemicals.		3-4
Level 1:	A simple description of using some of the equipment. Errors or omissions in science or in naming equipment or chemicals.		1-2
Level 0:	No relevant content		0
Indicative content			
• Acid in (conical) flask • Volume of acid measured using pipette • Indicator in (conical) flask • Suitable indicators include phenolphthalein / methyl orange / litmus • Colour change seen: phenolphthalein: colourless to pink methyl orange: yellow to red litmus: blue to red • Sodium hydroxide in burette • White tile under flask • Slow addition • Swirling • Volume of sodium hydroxide added • Repeat several times • Until at least three concordant results			