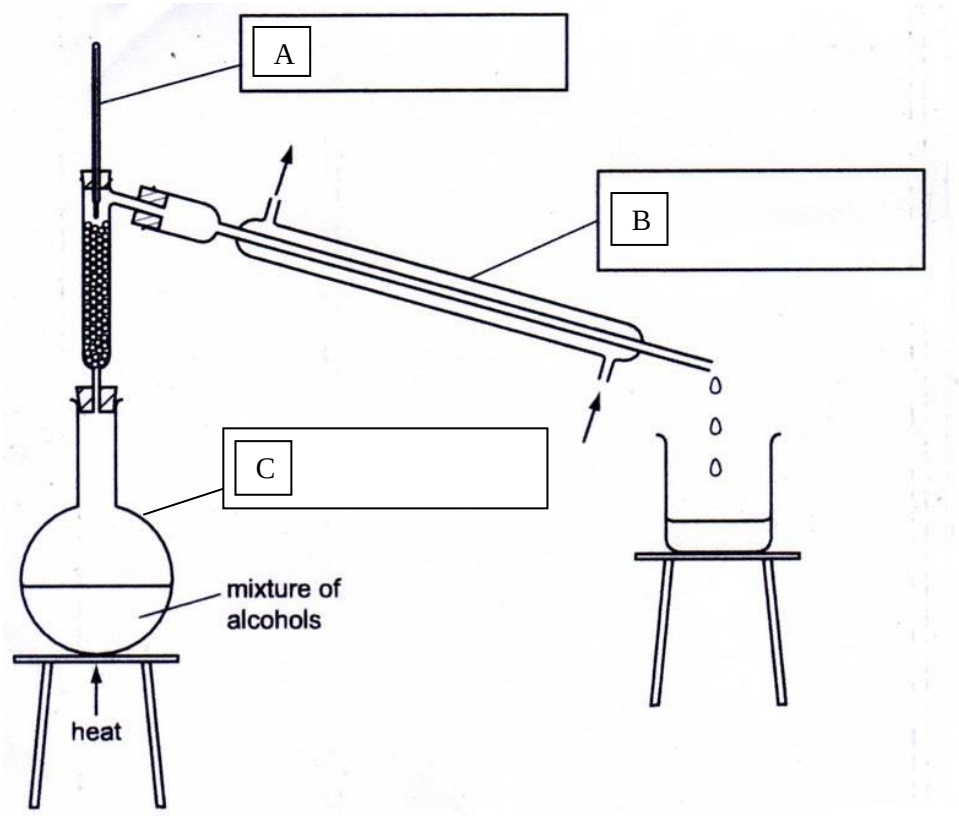
4-1 / 5-1 Atomic structure and the periodic table – Chemistry and Trilogy

1.0 A student separated a mixture of two alcohols, ethanol (boiling point 78 °C) and butanol (boiling point 118 °C).

The apparatus is shown in **Figure 1**.

Figure 1



1.1 Complete the boxes in **Figure 1** to identify the pieces of apparatus labelled A, B and C.

[3 marks]

1.2 What is the name of this separation process?

[1 mark]

_____

1.3 Suggest why the first liquid to collect in the beaker is ethanol.

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_____

1.4 Alcohols are flammable.
Suggest how the mixture of alcohols should be safely heated so that ethanol can be collected.

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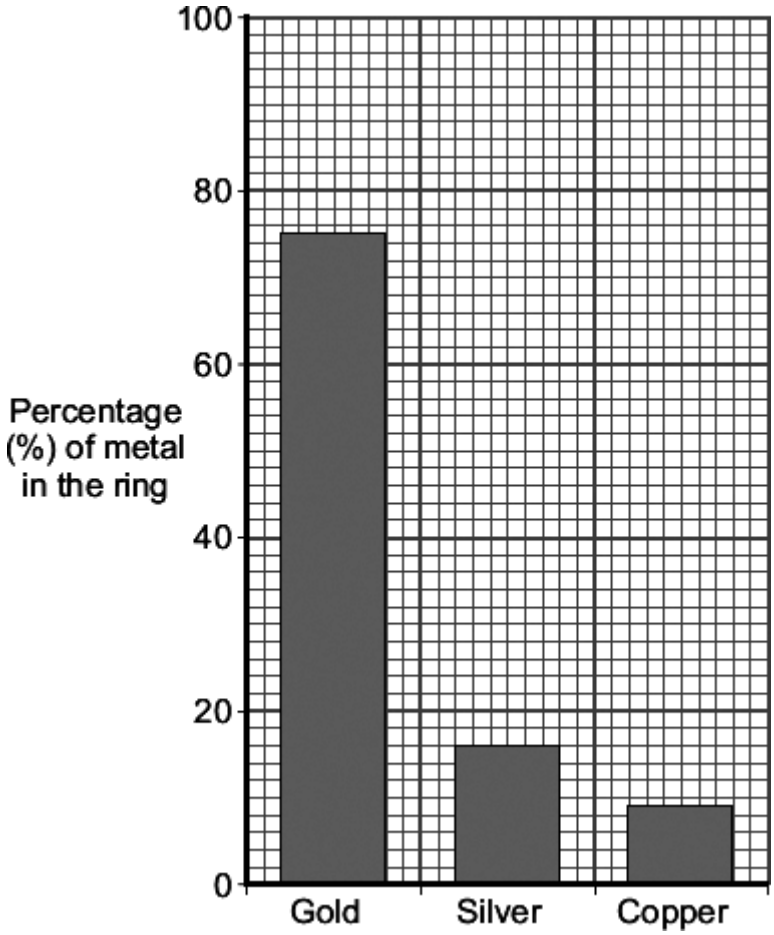
2.0 The picture shows a pair of gold rings.

Gold rings are made from alloys of gold.

Robert Chealb Creative commons license

The bar chart shows the composition of the alloy of gold used in the rings.



2.1 State the composition of the alloy used to make the rings.

[3 marks]

2.2 An atom of gold can be represented as $^{197}_{79}Au$.

This shows that a gold atom has an atomic number of 79 and a mass number of 197.

Complete the table to show the numbers of each sub-atomic particle in this gold atom.

[3 marks]

Name	Number
Proton	
Electron	
Neutron	

3.0 A student is given a mixture of salt and sand.

Describe a method the student could use to separate the mixture.

The student should obtain:

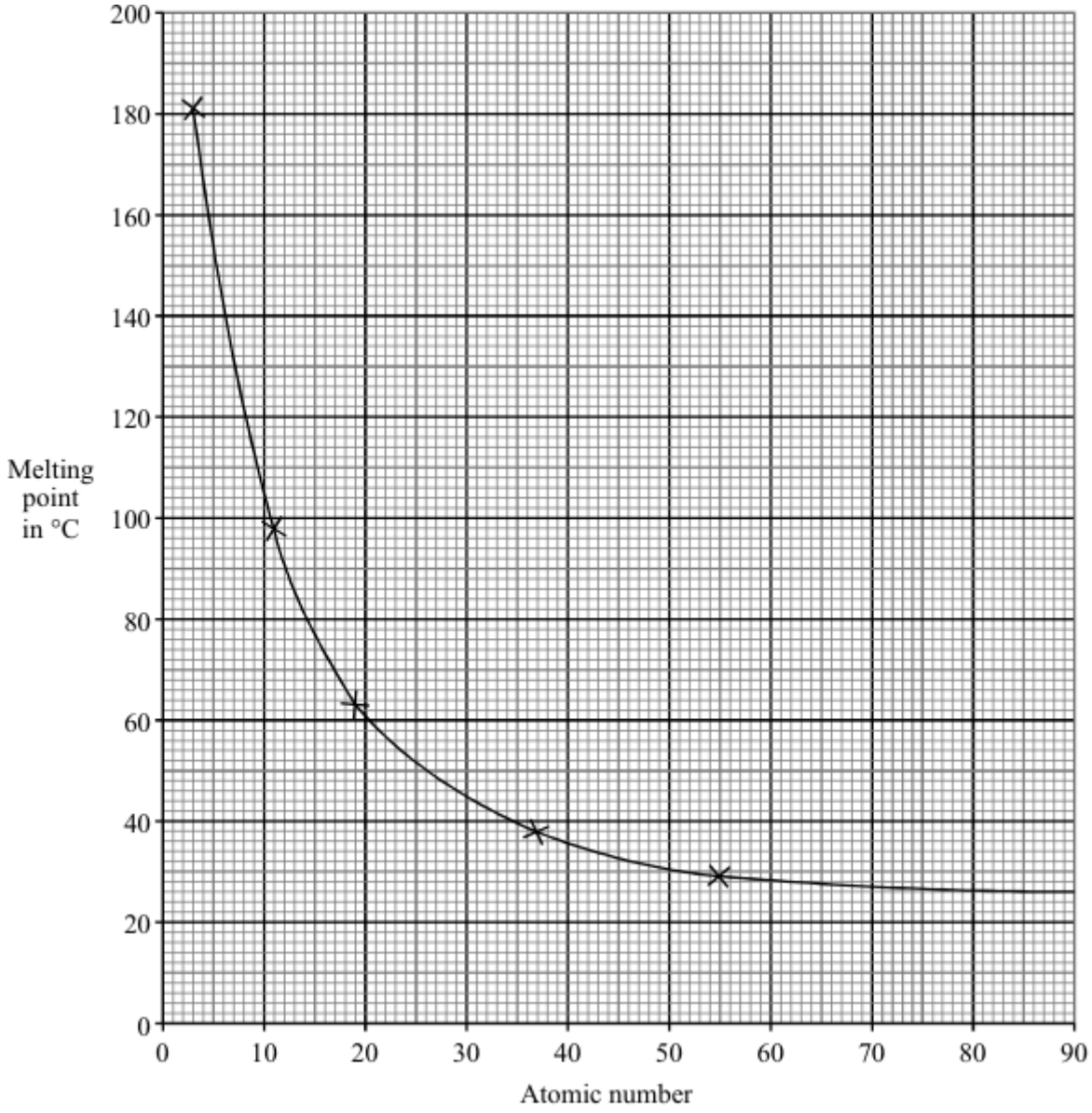
- salt crystals
- dry sand

In your method you should name all of the apparatus you will use.

[6 marks]

4.0 **Graph 1** shows the melting points of Group 1 metals plotted against their atomic numbers.

Graph 1



4.1 Give **two** conclusions that can be drawn from the graph.

[2 marks]

_____

_____

4.2 The alkali metal francium has an atomic number of 87.

Estimate the melting point of francium.

[1 mark]

Melting point of francium = _____ °C

4.3 Lithium has 3 electrons. Draw a diagram to show the electronic structure of lithium.

[1 mark]

4.4 Describe what you would see when sodium is added to water.

[3 marks]

_____

_____

_____

4.5 Complete the balanced equation for the reaction of sodium with water.

[2 marks]

_____ + _____ → _____ NaOH + H_2

4.6 Describe the trend in reactivity of group 1 metals with water.

[1 mark]

_____

4.7 Explain the trend in reactivity of group 1 metals with water.

[3 marks]

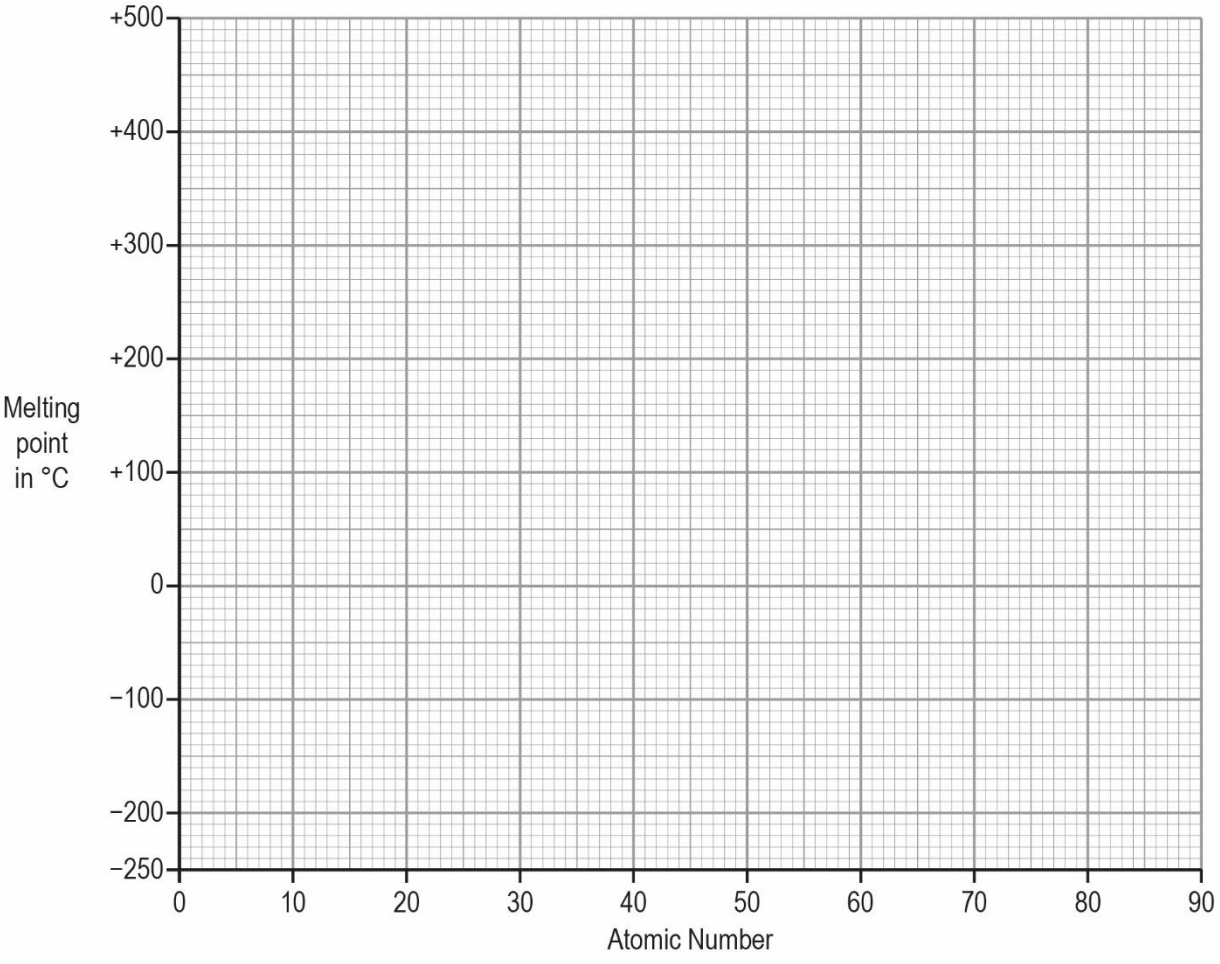
5.0 The table gives the melting points of some of the elements of Group 7.

Element	Atomic number	Melting point in °C
Fluorine	9	–220
Chlorine	17	
Bromine	35	–7
Iodine	53	114
Astatine	85	301

5.1 Plot a graph of the melting point against atomic number.

Draw a line of best fit.

[2 marks]



5.2 Estimate the melting point of chlorine.

[1 mark]

_____ °C

5.3 What is the state of iodine at 25 °C?

[1 mark]

_____

5.4 Chlorine has two isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$.
Why do these two isotopes have a different mass number?

[2 marks]

_____

_____

5.5 The relative formula mass of chlorine is 35.5.
Explain why this is not a whole number.

[1 mark]

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6.0 Dmitri Mendeleev was one of the first chemists to classify the elements.

Mendeleev arranged the elements in order of their atomic weight in a table.

Part of his table is shown below.

Use the periodic table and the information in the table below to help you to answer the questions.

	Group							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Period 1	H							
Period 2	Li	Be	B	C	N	O	F	
Period 3	Na	Mg	Al	Si	P	S	Cl	
Period 4	K Cu	Ca Zn	— —	Ti —	V As	Cr Se	Mn Br	Fe Co Ni

6.1 Which group of the modern periodic table is missing from Mendeleev's table?

[1 mark]

_____

6.2 Mendeleev placed hydrogen at the top of Group 1 in his version of the periodic table.
The modern periodic table does not show hydrogen in Group 1.
State one **similarity** between hydrogen and the elements in Group 1.

[1 mark]

_____

6.3 Mendeleev changed the position of iodine in his version of the periodic table so it was in the same group as chlorine.
Give **two** reasons why he put iodine in the same group as chlorine.

[2 marks]

_____

_____

6.4 Protons and electrons were discovered after Mendeleev proposed his version of the periodic table.
Describe how the numbers of protons and electrons in atoms are used to place elements in the modern periodic table.

[2 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	**A** Thermometer **B** (Liebig) condenser **C** (Round bottomed) flask	 allow conical flask	1 1 1
1.2	(Fractional) distillation		1
1.3	Has the lowest boiling point		1
1.4	Heat the mixture (in **C**) using a water bath/electric heater	accept description of water bath	1

Qu No.		Extra Information	Marks
2.1	75 % gold 16 % silver 9 % copper	 Allow chemical symbols If no other mark obtained, allow **1** mark for gold, silver and copper	1 1 1
2.2	(Proton) 79 (Electron) 79 (Neutron) 118		1 1 1

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Named apparatus • stirring rod • spatula • beaker • filter funnel and filter paper • evaporating basin • Bunsen burner • tripod and gauze • bench mat • beaker • oven Method • place mixture in a beaker • add water to the mixture • stir • filter the mixture • residue is sand • dry residue in a warm oven • evaporate some of the water from the filtrate (using a water bath) • allow solution (to cool and) to form crystals • remove and dry crystals			

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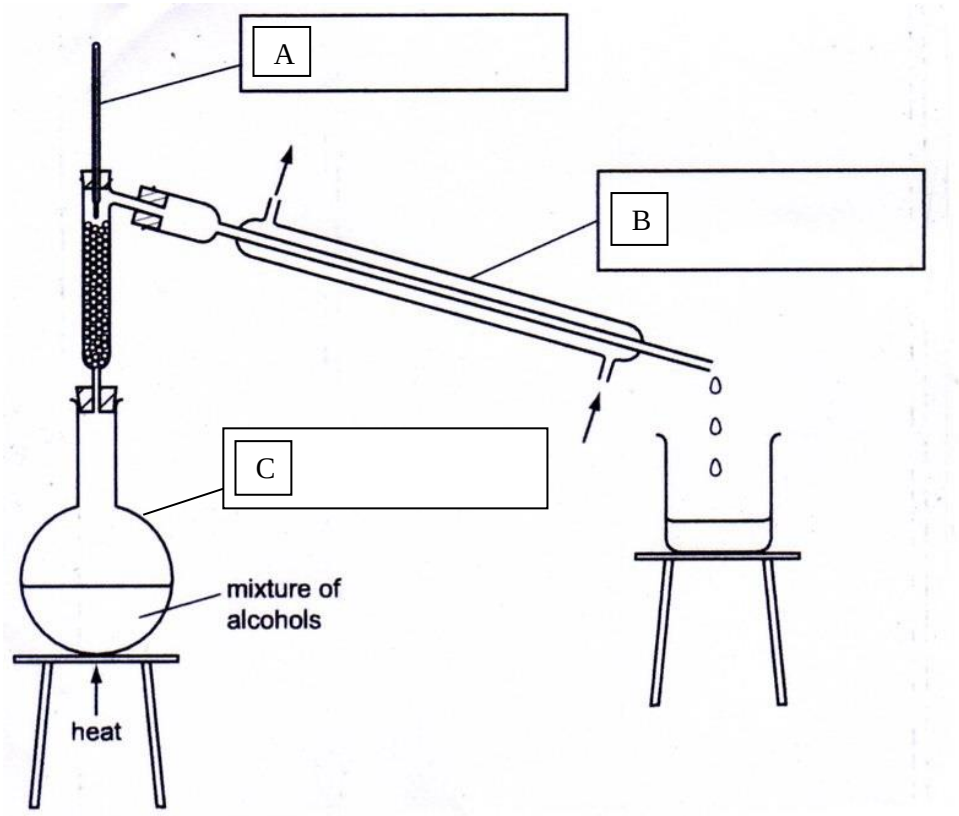

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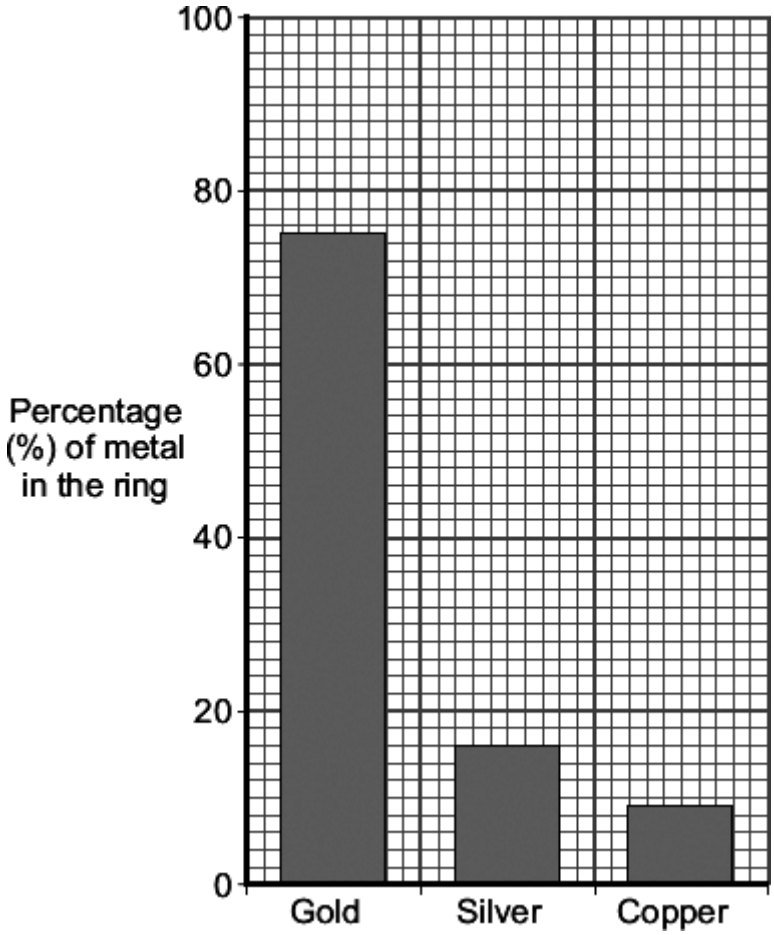

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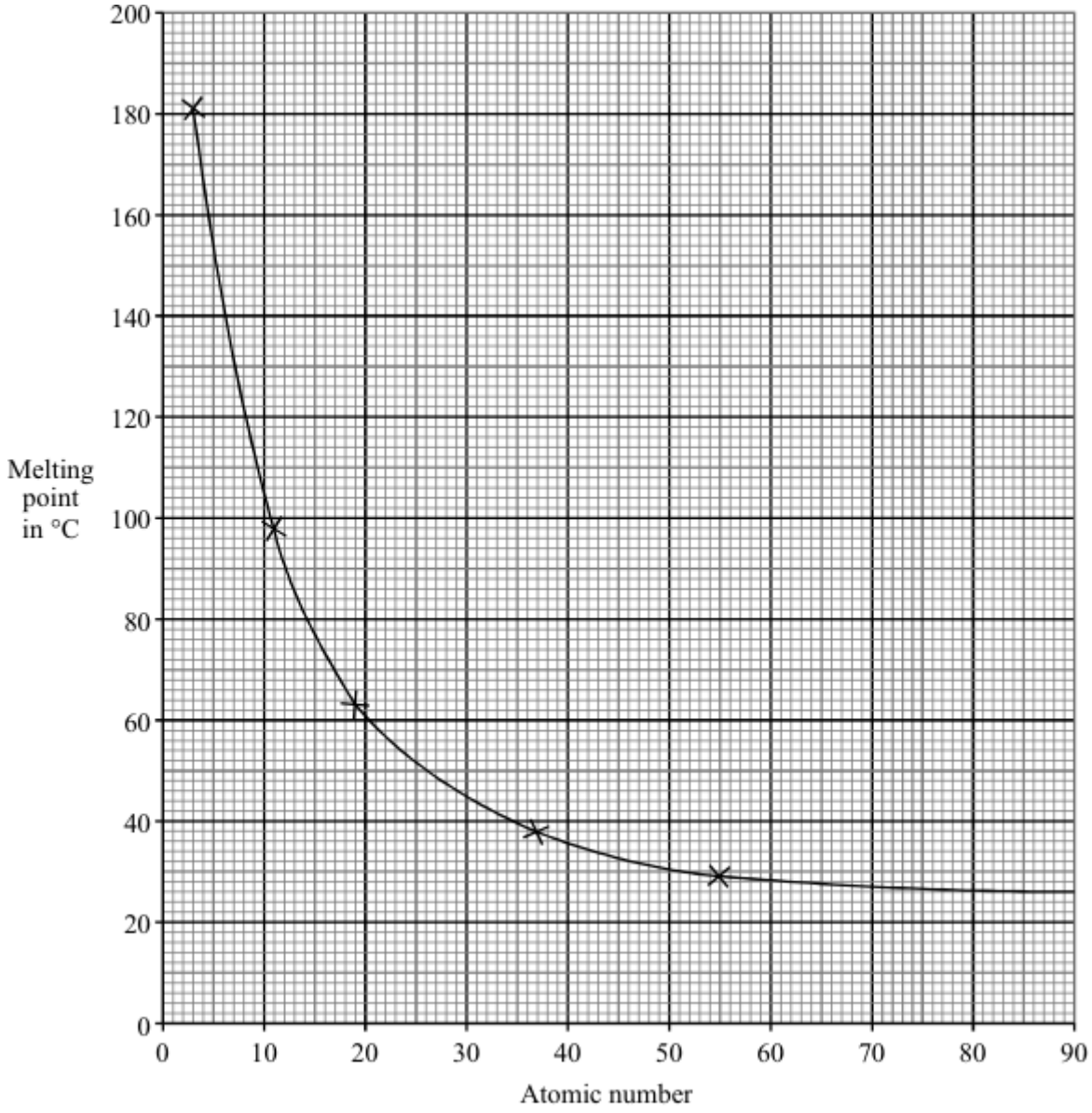

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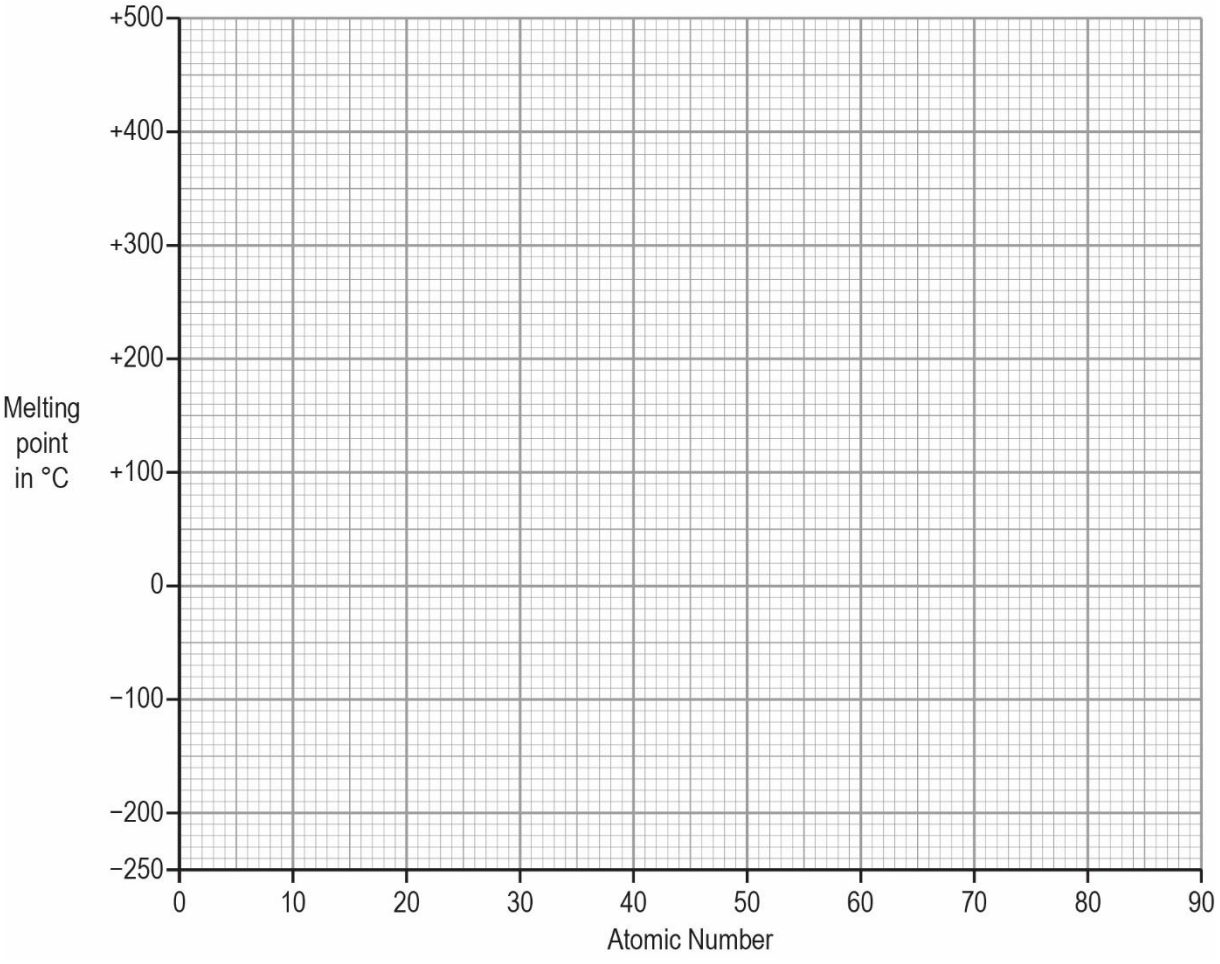

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6.4	(Elements) placed in order of atomic / proton number (Elements in) same group have same number of <u>outer</u> electrons		1 1

4-6 Chemistry /5-6 Trilogy – Rate and extent of chemical change

1.0 A student heated hydrated cobalt chloride.
The word equation shows the reaction.

hydrated cobalt chloride (pink) ⇌ anhydrous cobalt chloride (blue) + water

1.1 The student recorded some observations from this experiment.
Suggest **two** observations the student may have written down.

[2 marks]

_____

_____

1.2 The student added anhydrous cobalt chloride to water and measured the temperature rise.
The student's results are shown in the table below.

	Trial 1	**Trial 2**	**Trial 3**
Temperature rise in °C	9.5	9.2	9.2

Calculate the mean temperature rise.

[1 mark]

_____

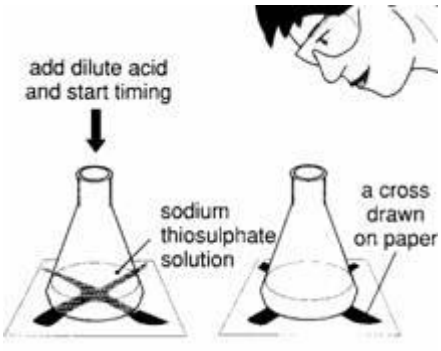
Temperature = _____ °C

1.3 During the reaction in **1.2**, the temperature increased.
Name the type of reaction that causes the temperature to rise.

[1 mark]

_____

2.0 A student investigated the effect of temperature on the rate of a reaction.
Figure 1 below shows the apparatus the student used.



2.1 Name a piece of apparatus which could be used to measure the volume of the acid.

[1 mark]

_____

2.2 The reaction forms a precipitate.
When should the student stop timing the reaction?

[1 mark]

_____

2.3 State the dependent and independent variables in the investigation.

[2 marks]

Dependent _____

Independent _____

2.4 The student only carried out each test once.
Explain why repeating the experiment would improve the results.

[1 mark]

_____

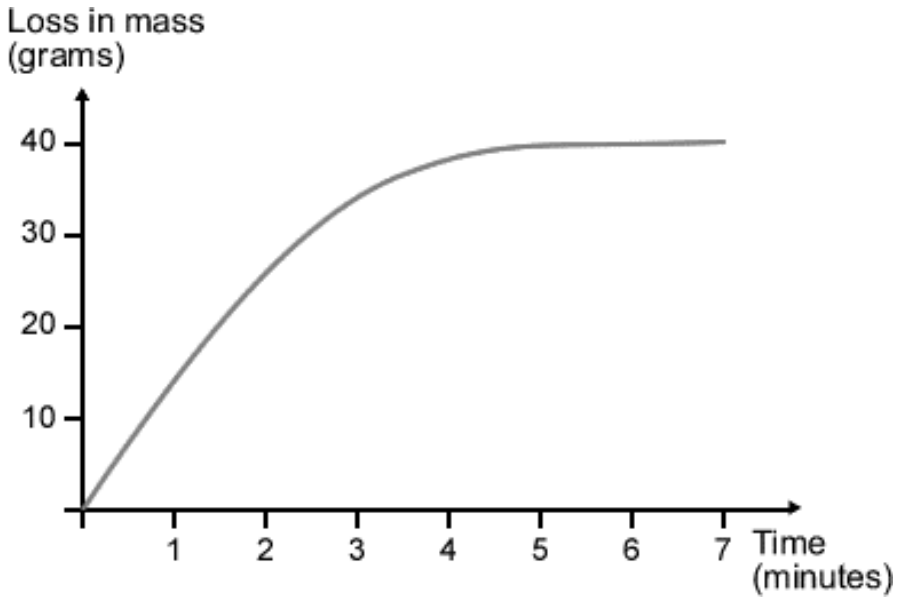
2.5 Describe how a preliminary investigation could be used to find an appropriate temperature range.

[2 marks]

_____

_____

2.6 Another student used a different experiment to investigate the rate of reaction.
This student measured the loss of mass every minute.
The student's results are shown in **Graph 1** below:



Add labels to the graph to show:

- when the reaction is complete
- when the rate of reaction is fastest
- when half the reactants have been used up.

[3 marks]

3.0 A student investigated how the concentration of hydrochloric acid affected the rate of reaction between hydrochloric acid (HCl) and magnesium ribbon to produce magnesium chloride ($MgCl_2$) and hydrogen (H_2).

3.1 Complete and balance the equation for the reaction:

[2 marks]

_____(s) + _____(aq) → _____(aq) + _____(g)

Figure 2 below shows the apparatus the student used.

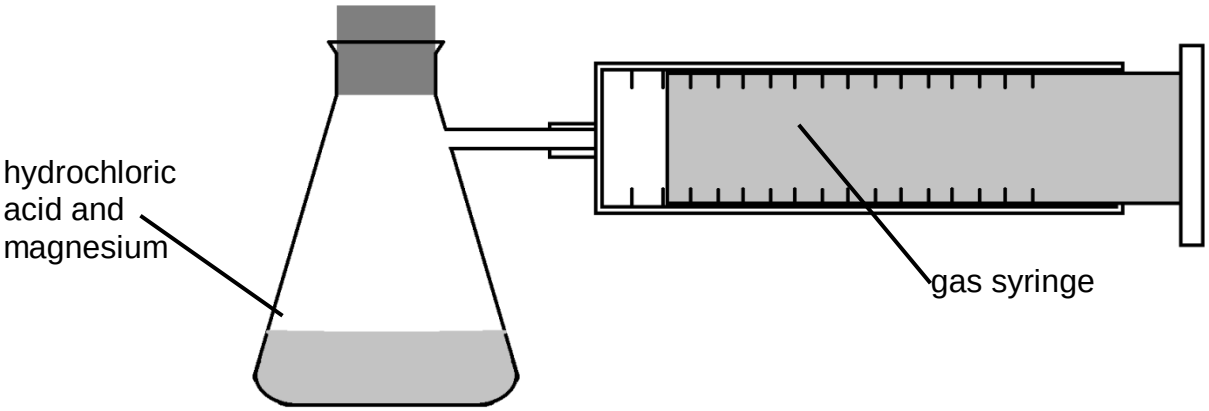


Table 1 shows the results of the experiment.

Table 1

Concentration of hydrochloric acid in mol/dm^3	Time taken for 30 cm^3 of hydrogen to be produced in s				Mean rate of reaction in cm^3/s
	Trial 1	Trial 2	Trial 3	Mean	
0.4	158	150	154	154	0.19
0.8	77	77	74	76	0.39
1.2	68	51	49		
1.6	37	39	38	38	0.79
2.0	30	29	31	30	1.00

3.2 Calculate the rate of reaction when 1.2 mol/dm^3 hydrochloric acid is added to magnesium.

Use the equation below.

$$\text{mean rate of reaction} = \frac{\text{volume of gas in cm}^3}{\text{mean time taken in s}}$$

[3 marks]

Mean rate of reaction = _____ cm^3/s

3.3 Give **two** variables which the student should control during this investigation.

[2 marks]

_____

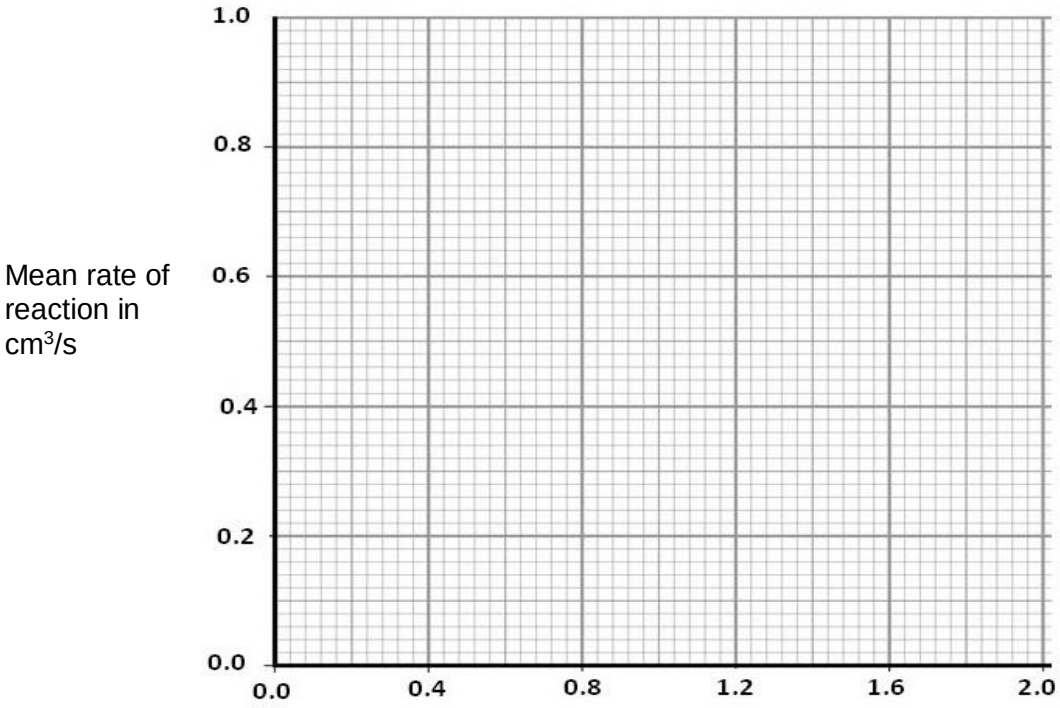
_____

3.4 On **Figure 3,** use the results from **Table 1** to

- plot a graph of rate of reaction and concentration of acid
- draw a best fit line

[3 marks

Figure 3



3.5 Using the idea of particle collisions, explain why the reaction rate is faster when the concentration of the acid is greater.

[2 marks]

_____

_____

3.6 The student used magnesium ribbon.
State a change that could be made to the magnesium to speed up the reaction.

[1 mark]

_____

3.7 Explain in terms of the particles why the change you gave in **3.6** would increase the speed of reaction.

[1 mark]

_____

4.0 This question is about reversible reactions and chemical equilibrium.

4.1 Reversible reactions can reach equilibrium in a closed system.
What is meant by a **closed system**?

[1 mark]

_____

4.2 Explain why a reaction seems to have finished when a reversible reaction reaches equilibrium.

[2 marks]

_____

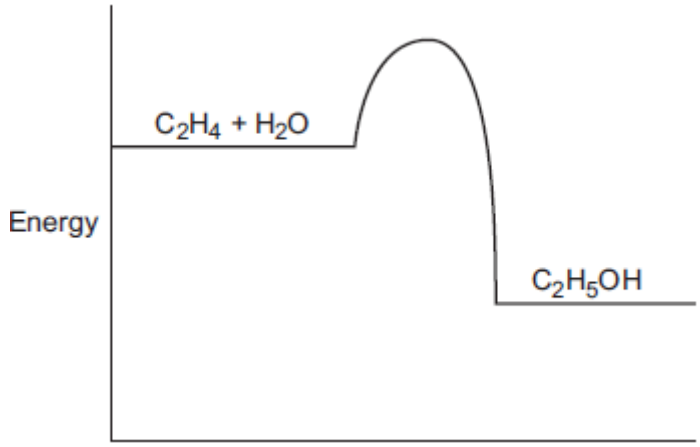
_____

Ethanol can be produced in a reversible reaction from ethene and steam.
The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

Figure 4 shows the reaction profile for the reaction.

Figure 4



4.3 How does the diagram show that the reaction is exothermic?

[1 mark]

_____

4.4 A catalyst can be used for the reaction.
Indicate on **Figure 4**:

- the reaction profile for a catalysed reaction
- the activation energy for a catalysed reaction.

[2 marks]

4.5 State what is meant by **activation energy**.

[1 mark]

_____

_____

4.6 Give one similarity and one difference in the energy transfer for the back reaction to form ethene and water from ethanol.

[2 marks]

Similarity: _____

Difference: _____

4.7 A company manufactures ethanol (C_2H_3OH).

The reaction for the process is:

$$C_2H_4\,(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.
The forward reaction is exothermic.
The conditions used in the process are:

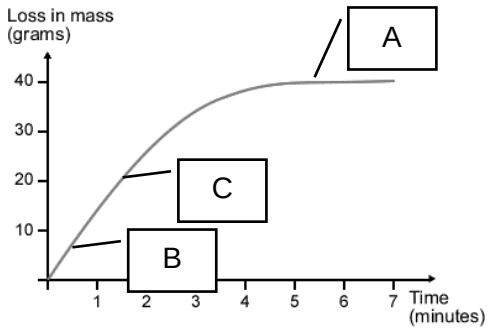
- 60 atmospheres pressure
- 200 °C
- phosphoric acid catalyst.

Explain why these conditions are used in this process.
Use the equation and your knowledge of reversible reactions
Consider **both** yield **and** rate of reaction in your answer.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	(solid) changes from pink to blue Droplets of water / steam		1 1
1.2	9.3 °C		1
1.3	Exothermic		1

Qu No.		Extra Information	Marks
2.1	Measuring cylinder	Allow burette/pipette	1
2.2	When the cross cannot be seen through the solution	ignore when the solution is cloudy	1
2.3	(dependent) Time taken for the cross to disappear (independent) Temperature		 1 1
2.4	To check the results. So you know the readings are accurate. To eliminate/ignore anomalous results.	Allow to improve reliability.	1
2.5	Two temperatures are suggested that constitute a range Understanding demonstrated that an appropriate range will allow a pattern or trend to be seen in the results		1 1
2.6	**Graph 1**  A: reaction is complete B: reaction is fastest C: half the reactants have been used up.	A: Must be after graph levels off B: Any point on straight line up before it changes gradient C: When loss of mass is 20g	1 1 1

Qu No.		Extra Information	Marks
3.1	Formulae in correct place Correct balancing	 Allow 2 marks for $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$	1 1
3.2	(49+51)/2 (mean =) 50 (30/50 =) 0.60	 Allow 2 marks for 50 without working Allow 2 marks for 0.54 where anomaly has been included in mean	1 1 1
3.3	any **two** from: • volume of acid • temperature (of acid) • length of magnesium (ribbon)	Do not allow concentration of acid allow mass of magnesium ribbon	2
3.4	All points plotted correctly Best fit straight line	± ½ small square Allow 1 mark for 4 plotted correctly Allow ecf for anomalous point at (1.2,0.54) Should not be influenced by anomaly	2 1
3.5	Particles must collide in order to react Collision frequency increases as concentration increases		1 1
3.6	cut it up **or** increase the surface area	Allow grind it up **or** make a powder do **not** accept make it smaller **or** use a smaller piece	1
3.7	Reference to particle theory eg more collisions between acid ions/particles and atoms/particles of magnesium		1

Qu No.		Extra Information	Marks
4.1	nothing can enter and nothing can leave the reaction	allow sealed reaction vessel	1
4.2	at equilibrium the forward and backward reactions have same rate so there is no (overall) change in quantities of reactants and products		1 1
4.3	the products are at a lower energy level than the reactants	accept products have less energy or less energy at the end than the beginning	1
4.4	Pathway drawn from reactants to products, below original pathway Indication of activation energy from reactant level to highest point on catalysed reaction pathway		1 1
4.5	Minimum amount of energy needed by particles to react		1
4.6	*Similarity* Same amount of energy transferred *Difference* Endothermic reaction	 Allow 45 kJ of energy transferred (given in 4.7 below) Allow energy taken in by reaction	 1 1

4.7			
Level 3:	A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
60 atmospheres pressure • high pressure gives a high yield of ethanol • too high a pressure causes risk of explosion • high pressure costly to maintain • a high pressure will cause the rate to be higher • 2 moles of gas become 1 (or fewer moles of gas in products) **200 °C** • high temperature increases the rate of reaction • optimum temperature • (forward reaction is exothermic so) a high yield of ethanol requires a low temperature • but too low a temperature causes the rate of reaction to be too slow **phosphoric acid catalyst** • a catalyst speeds up the reaction a phosphoric acid catalyst allows a lower temperature to be used (saving energy and causing a higher yield) • phosphoric acid catalyst increases the rate of reaction equally in both reactions **others** • compromise conditions • unreacted ethene and steam is recycled			

4-6 Chemistry /5-6 Trilogy – Rate and extent of chemical change

1.0 A student heated hydrated cobalt chloride.
The word equation shows the reaction.

hydrated cobalt chloride (pink) ⇌ anhydrous cobalt chloride (blue) + water

1.1 The student recorded some observations from this experiment.
Suggest **two** observations the student may have written down.

[2 marks]

_____

_____

1.2 The student added anhydrous cobalt chloride to water and measured the temperature rise.
The student's results are shown in the table below.

	Trial 1	**Trial 2**	**Trial 3**
Temperature rise in °C	9.5	9.2	9.2

Calculate the mean temperature rise.

[1 mark]

_____

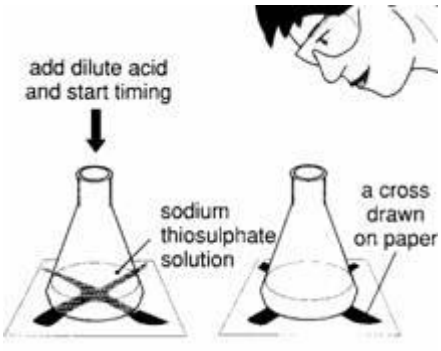
Temperature = _____ °C

1.3 During the reaction in **1.2**, the temperature increased.
Name the type of reaction that causes the temperature to rise.

[1 mark]

_____

2.0 A student investigated the effect of temperature on the rate of a reaction.
Figure 1 below shows the apparatus the student used.



2.1 Name a piece of apparatus which could be used to measure the volume of the acid.

[1 mark]

_____

2.2 The reaction forms a precipitate.
When should the student stop timing the reaction?

[1 mark]

_____

2.3 State the dependent and independent variables in the investigation.

[2 marks]

Dependent _____

Independent _____

2.4 The student only carried out each test once.
Explain why repeating the experiment would improve the results.

[1 mark]

_____

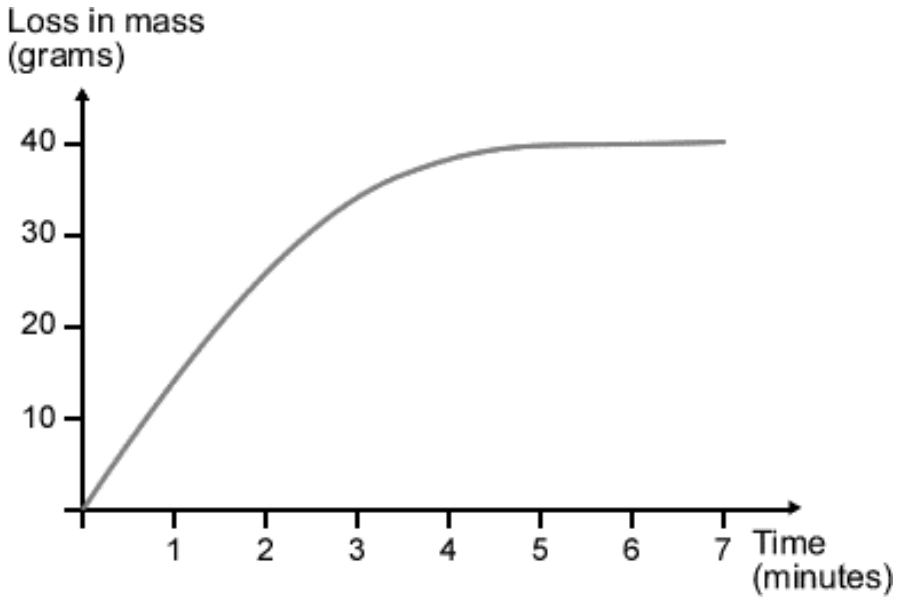
2.5 Describe how a preliminary investigation could be used to find an appropriate temperature range.

[2 marks]

_____

_____

2.6 Another student used a different experiment to investigate the rate of reaction.
This student measured the loss of mass every minute.
The student's results are shown in **Graph 1** below:



Add labels to the graph to show:

- when the reaction is complete
- when the rate of reaction is fastest
- when half the reactants have been used up.

[3 marks]

3.0 A student investigated how the concentration of hydrochloric acid affected the rate of reaction between hydrochloric acid (HCl) and magnesium ribbon to produce magnesium chloride ($MgCl_2$) and hydrogen (H_2).

3.1 Complete and balance the equation for the reaction:

[2 marks]

_____(s) + _____(aq) → _____(aq) + _____(g)

Figure 2 below shows the apparatus the student used.

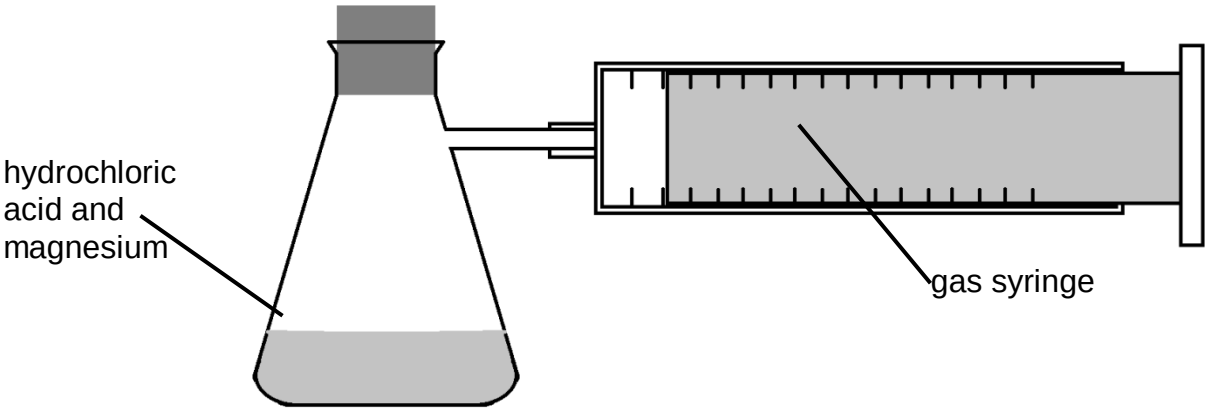


Table 1 shows the results of the experiment.

Table 1

Concentration of hydrochloric acid in mol/dm^3	Time taken for 30 cm^3 of hydrogen to be produced in s				Mean rate of reaction in cm^3/s
	Trial 1	Trial 2	Trial 3	Mean	
0.4	158	150	154	154	0.19
0.8	77	77	74	76	0.39
1.2	68	51	49		
1.6	37	39	38	38	0.79
2.0	30	29	31	30	1.00

3.2 Calculate the rate of reaction when 1.2 mol/dm^3 hydrochloric acid is added to magnesium.

Use the equation below.

$$\text{mean rate of reaction} = \frac{\text{volume of gas in cm}^3}{\text{mean time taken in s}}$$

[3 marks]

Mean rate of reaction = _____ cm^3/s

3.3 Give **two** variables which the student should control during this investigation.

[2 marks]

_____

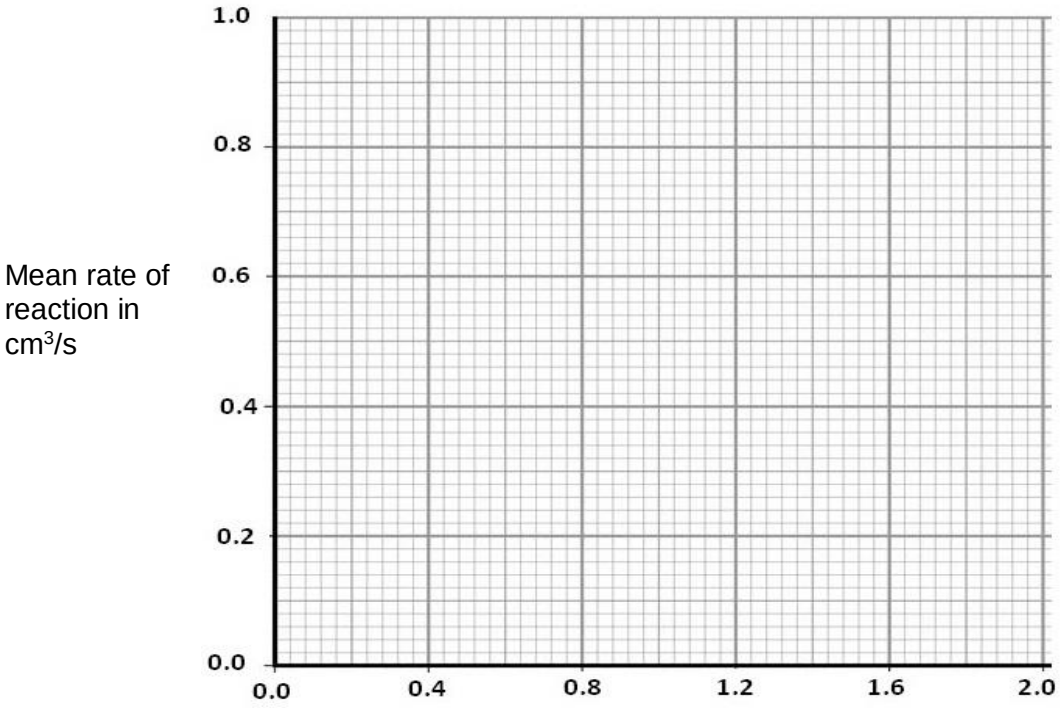
_____

3.4 On **Figure 3,** use the results from **Table 1** to

- plot a graph of rate of reaction and concentration of acid
- draw a best fit line

[3 marks

Figure 3



3.5 Using the idea of particle collisions, explain why the reaction rate is faster when the concentration of the acid is greater.

[2 marks]

_____

_____

3.6 The student used magnesium ribbon.
State a change that could be made to the magnesium to speed up the reaction.

[1 mark]

_____

3.7 Explain in terms of the particles why the change you gave in **3.6** would increase the speed of reaction.

[1 mark]

_____

4.0 This question is about reversible reactions and chemical equilibrium.

4.1 Reversible reactions can reach equilibrium in a closed system.
What is meant by a **closed system**?

[1 mark]

_____

4.2 Explain why a reaction seems to have finished when a reversible reaction reaches equilibrium.

[2 marks]

_____

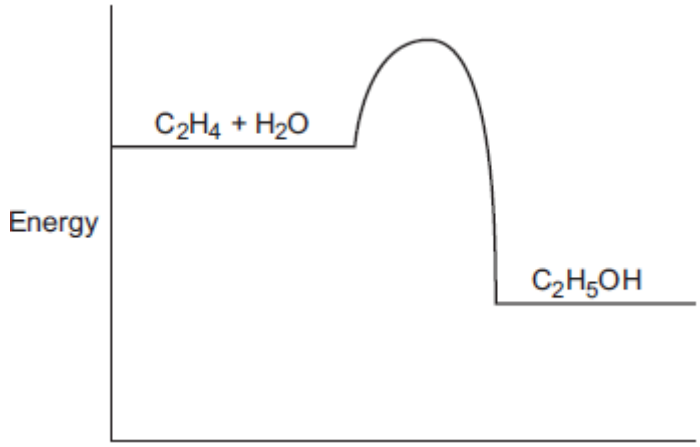
_____

Ethanol can be produced in a reversible reaction from ethene and steam.
The equation for the reaction is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

Figure 4 shows the reaction profile for the reaction.

Figure 4



4.3 How does the diagram show that the reaction is exothermic?

[1 mark]

_____

4.4 A catalyst can be used for the reaction.
Indicate on **Figure 4**:

- the reaction profile for a catalysed reaction
- the activation energy for a catalysed reaction.

[2 marks]

4.5 State what is meant by **activation energy**.

[1 mark]

_____

_____

4.6 Give one similarity and one difference in the energy transfer for the back reaction to form ethene and water from ethanol.

[2 marks]

Similarity: _____

Difference: _____

4.7 A company manufactures ethanol (C_2H_3OH).

The reaction for the process is:

$$C_2H_4\,(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.
The forward reaction is exothermic.
The conditions used in the process are:

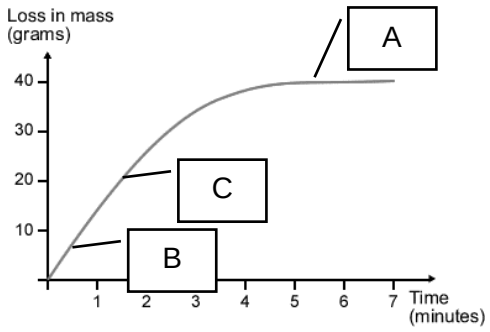
- 60 atmospheres pressure
- 200 °C
- phosphoric acid catalyst.

Explain why these conditions are used in this process.
Use the equation and your knowledge of reversible reactions
Consider **both** yield **and** rate of reaction in your answer.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	(solid) changes from pink to blue Droplets of water / steam		1 1
1.2	9.3 °C		1
1.3	Exothermic		1

Qu No.		Extra Information	Marks
2.1	Measuring cylinder	Allow burette/pipette	1
2.2	When the cross cannot be seen through the solution	ignore when the solution is cloudy	1
2.3	(dependent) Time taken for the cross to disappear (independent) Temperature		 1 1
2.4	To check the results. So you know the readings are accurate. To eliminate/ignore anomalous results.	Allow to improve reliability.	1
2.5	Two temperatures are suggested that constitute a range Understanding demonstrated that an appropriate range will allow a pattern or trend to be seen in the results		1 1
2.6	**Graph 1**  A: reaction is complete B: reaction is fastest C: half the reactants have been used up.	A: Must be after graph levels off B: Any point on straight line up before it changes gradient C: When loss of mass is 20g	1 1 1

Qu No.		Extra Information	Marks
3.1	Formulae in correct place Correct balancing	 Allow 2 marks for $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$	1 1
3.2	(49+51)/2 (mean =) 50 (30/50 =) 0.60	 Allow 2 marks for 50 without working Allow 2 marks for 0.54 where anomaly has been included in mean	1 1 1
3.3	any **two** from: • volume of acid • temperature (of acid) • length of magnesium (ribbon)	Do not allow concentration of acid allow mass of magnesium ribbon	2
3.4	All points plotted correctly Best fit straight line	± ½ small square Allow 1 mark for 4 plotted correctly Allow ecf for anomalous point at (1.2,0.54) Should not be influenced by anomaly	2 1
3.5	Particles must collide in order to react Collision frequency increases as concentration increases		1 1
3.6	cut it up **or** increase the surface area	Allow grind it up **or** make a powder do **not** accept make it smaller **or** use a smaller piece	1
3.7	Reference to particle theory eg more collisions between acid ions/particles and atoms/particles of magnesium		1

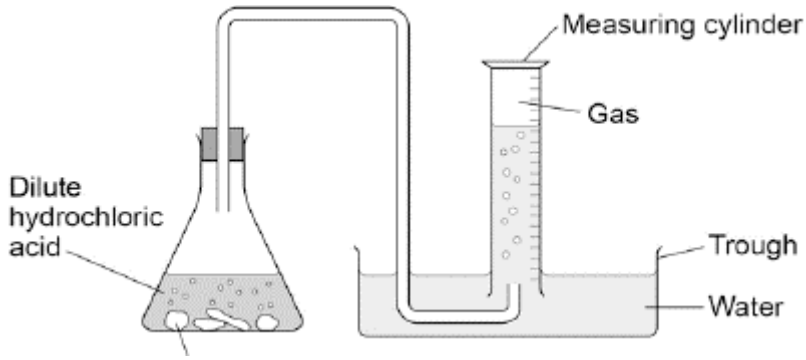
Qu No.		Extra Information	Marks
4.1	nothing can enter and nothing can leave the reaction	allow sealed reaction vessel	1
4.2	at equilibrium the forward and backward reactions have same rate so there is no (overall) change in quantities of reactants and products		1 1
4.3	the products are at a lower energy level than the reactants	accept products have less energy or less energy at the end than the beginning	1
4.4	Pathway drawn from reactants to products, below original pathway Indication of activation energy from reactant level to highest point on catalysed reaction pathway		1 1
4.5	Minimum amount of energy needed by particles to react		1
4.6	*Similarity* Same amount of energy transferred *Difference* Endothermic reaction	 Allow 45 kJ of energy transferred (given in 4.7 below) Allow energy taken in by reaction	 1 1

4.7			
Level 3:	A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
60 atmospheres pressure • high pressure gives a high yield of ethanol • too high a pressure causes risk of explosion • high pressure costly to maintain • a high pressure will cause the rate to be higher • 2 moles of gas become 1 (or fewer moles of gas in products) **200 °C** • high temperature increases the rate of reaction • optimum temperature • (forward reaction is exothermic so) a high yield of ethanol requires a low temperature • but too low a temperature causes the rate of reaction to be too slow **phosphoric acid catalyst** • a catalyst speeds up the reaction a phosphoric acid catalyst allows a lower temperature to be used (saving energy and causing a higher yield) • phosphoric acid catalyst increases the rate of reaction equally in both reactions **others** • compromise conditions • unreacted ethene and steam is recycled			

5-4 Chemical changes – Trilogy

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)

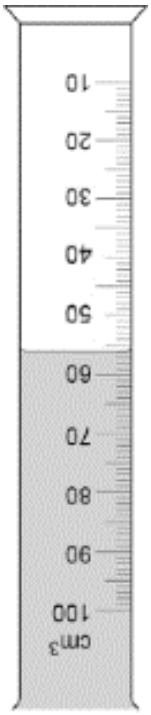
1.2 Name the substance produced as a gas.

[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

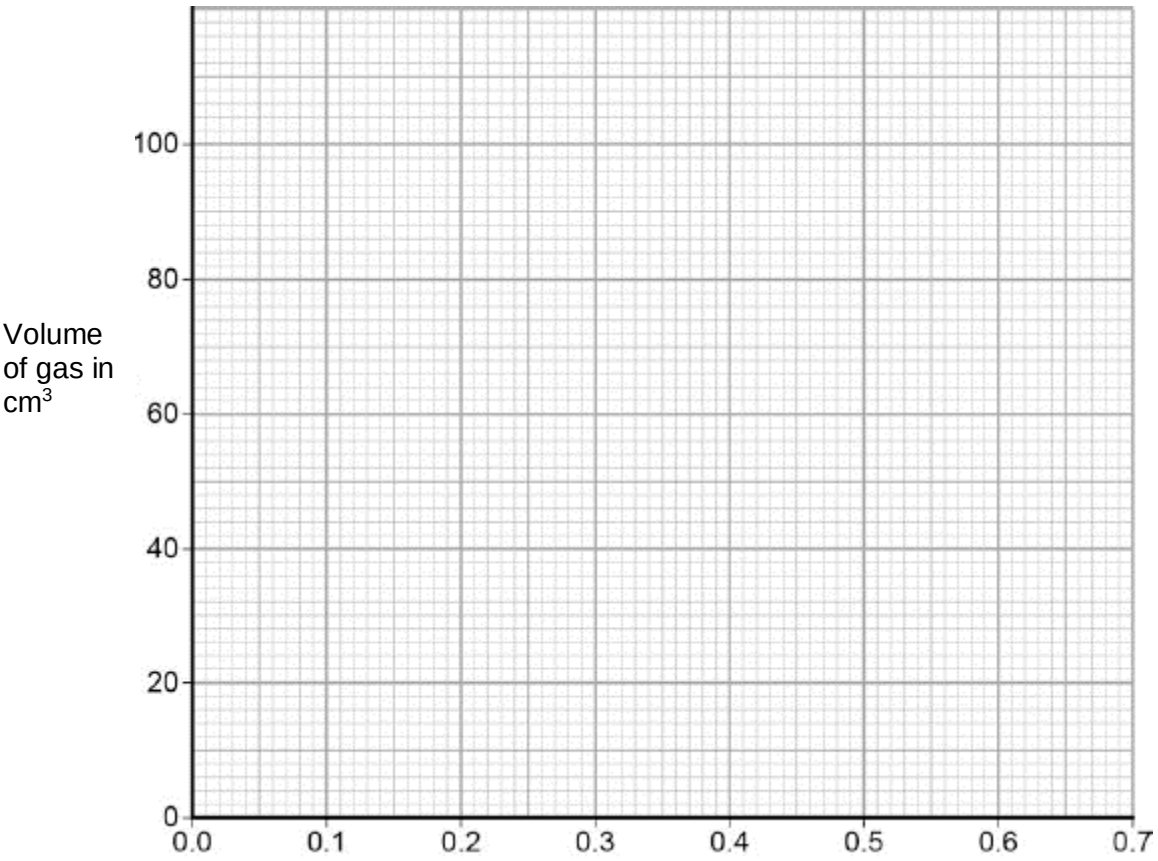
Mass of sodium carbonate in g	Volume of gas in cm^3
0.0	0
0.1	23
0.2	28
0.3	69
0.4	92
0.5	98
0.6	98
0.7	98

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.

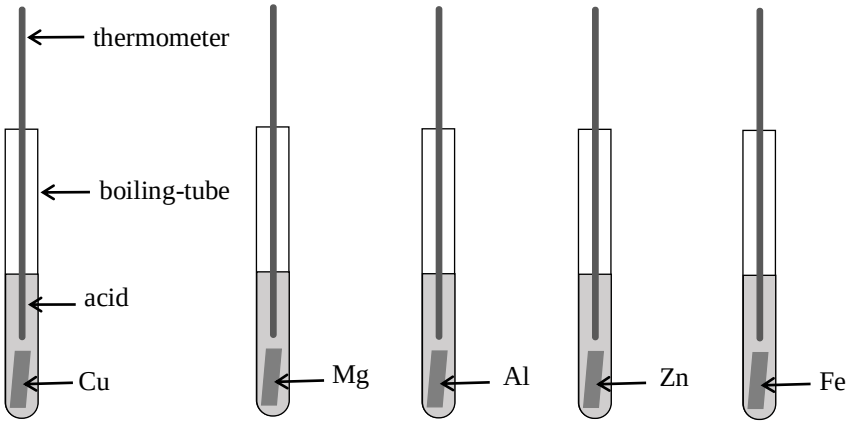
[2 marks]

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 50cm^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]

_____

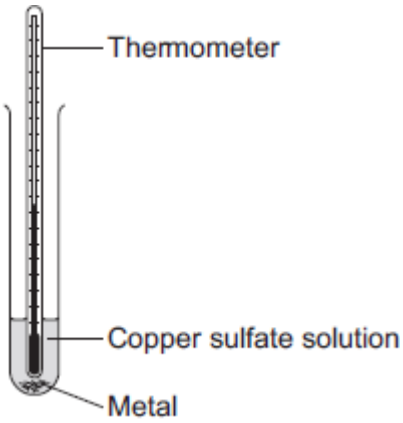
3.6 Suggest why the student did not use any Group 1 metals in the investigation.

[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.

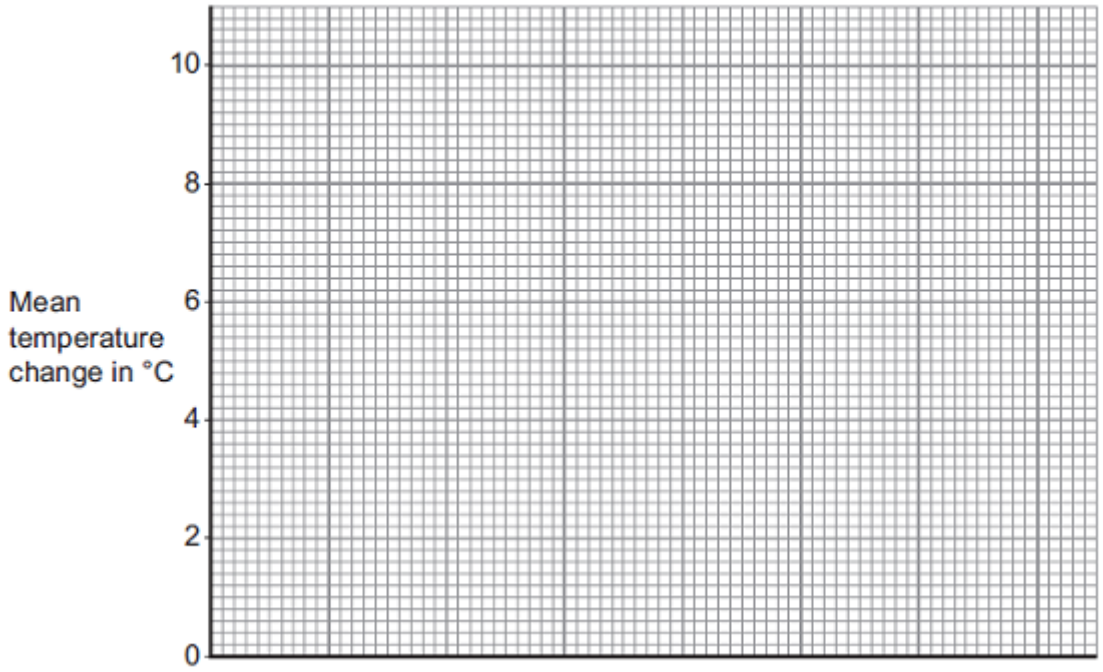
Table 2

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]

_____

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

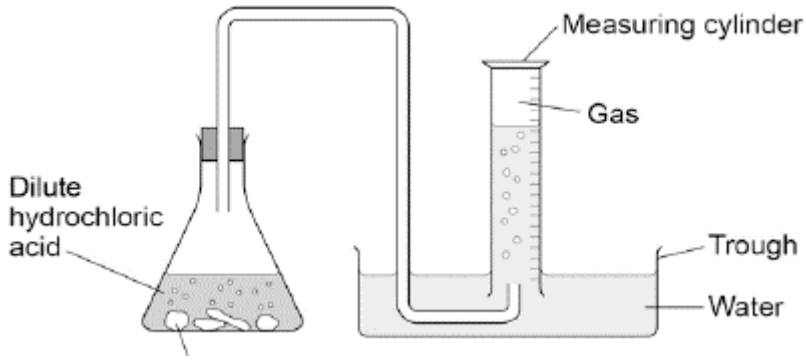
Qu No.		Extra Information	Marks
5.1	$Mg^{2+} + 2e^- \rightarrow Mg$	Allow **1** mark for e^-	2
5.2	Chloride ions attracted to positive electrode (where they) lose electrons chlorine atom / molecule produced		1 1 1 1
5.3	Magnesium too reactive or Carbon not reactive enough		1
5.4	Magnesium ions and hydrogen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

5-4 Chemical changes – Trilogy

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)

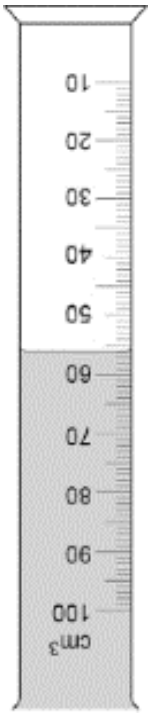
1.2 Name the substance produced as a gas.

[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

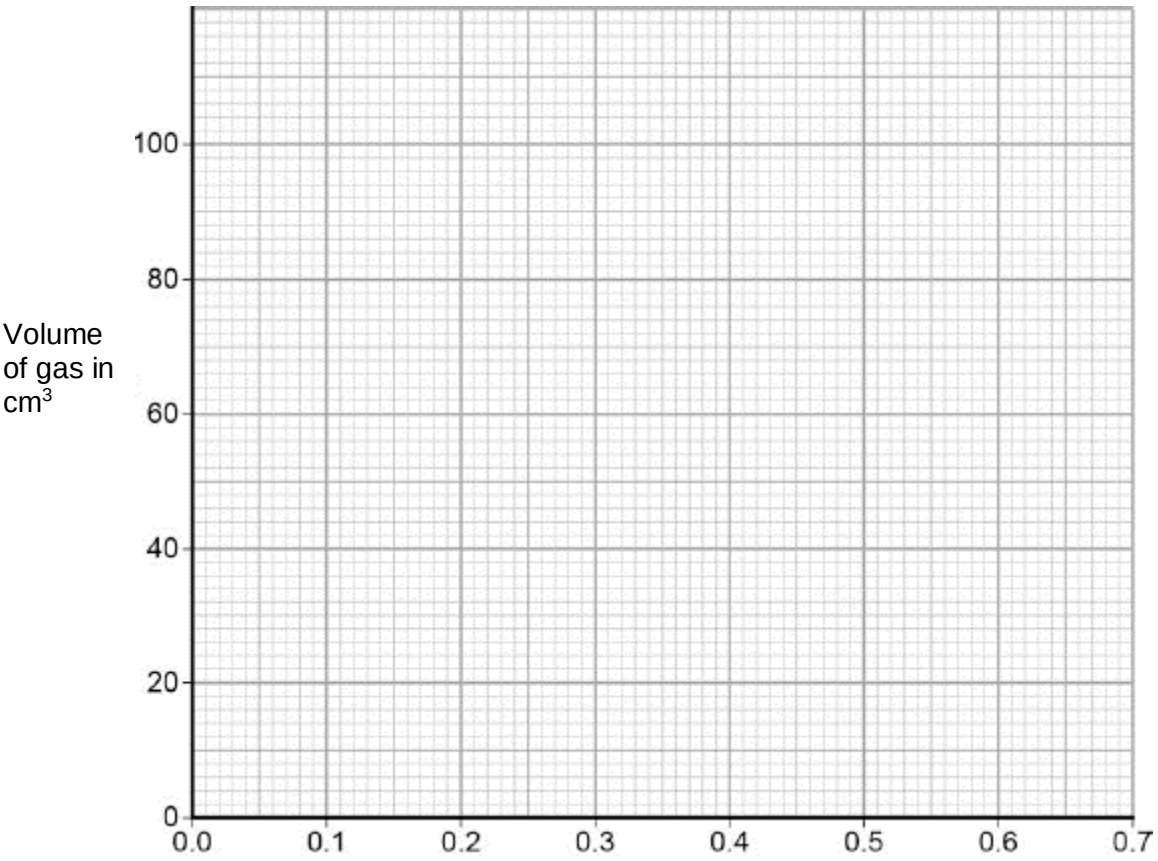
Mass of sodium carbonate in g	Volume of gas in cm^3
0.0	0
0.1	23
0.2	28
0.3	69
0.4	92
0.5	98
0.6	98
0.7	98

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.

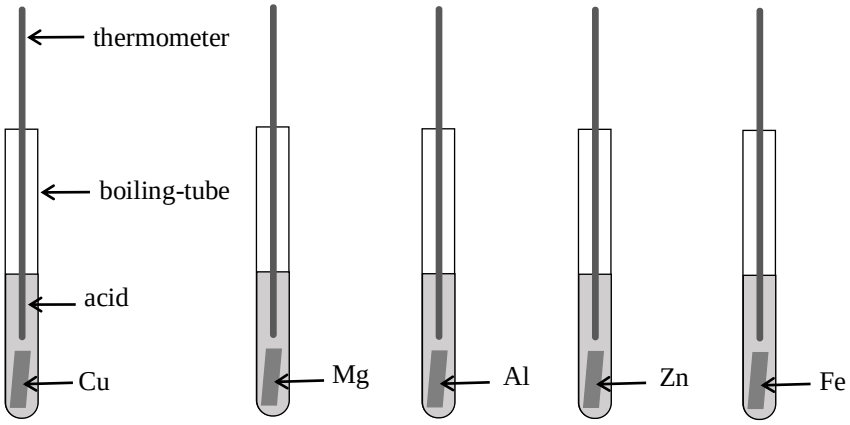
[2 marks]

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 50cm^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]

_____

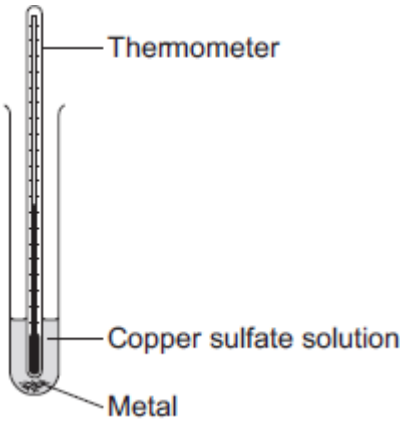
3.6 Suggest why the student did not use any Group 1 metals in the investigation.

[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.

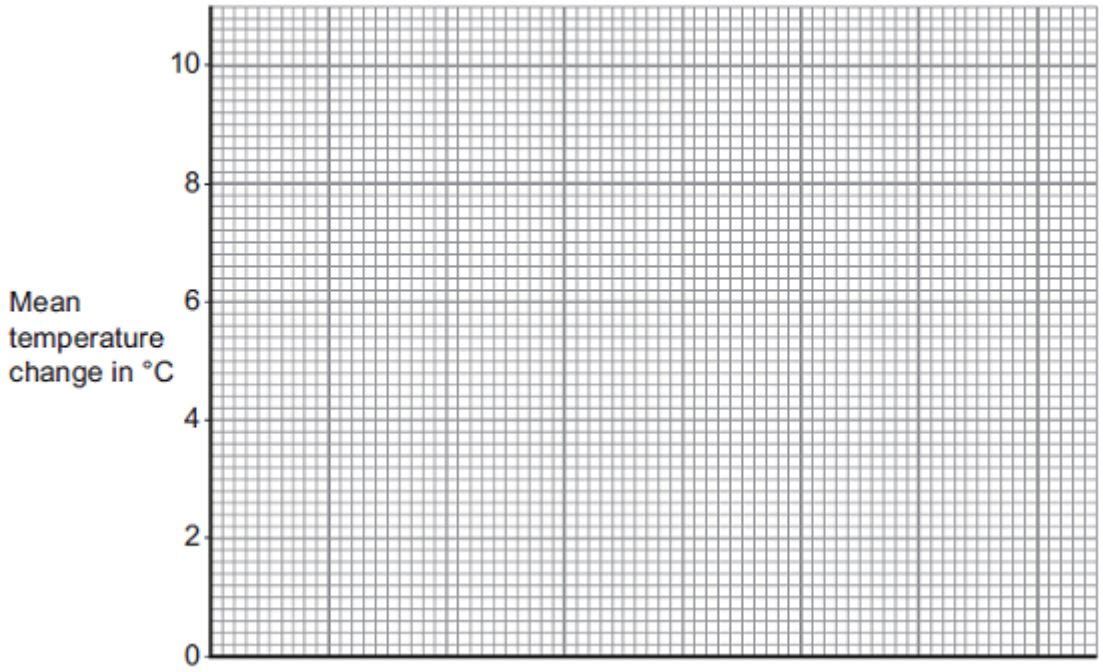
Table 2

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]

_____

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

5-5 Energy Changes – Trilogy

1.0 The **Figure 1** shows magnesium burning in air.

Figure 1

© Charles D Winters/Science Photo Library

1.1 Give **one** observation that you can make from **Figure 1** that shows that a chemical reaction is taking place.

[1 mark]

_____

1.2 The Bunsen burner flame provides energy to start the magnesium burning.

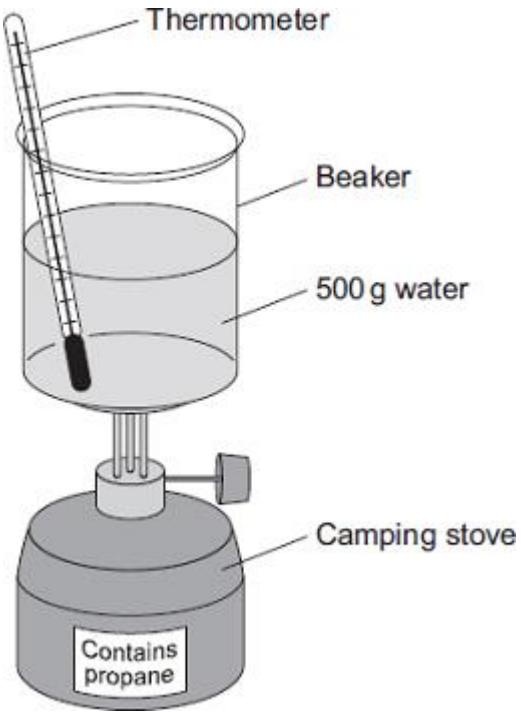
Draw a ring around the name given to the energy needed to start a chemical reaction.

[1 mark]

Activation energy **Potential Energy** **Solar Energy**

2.0 A camping stove uses propane gas.

A student investigated the energy released when propane gas is burnt.



The student:

- put 500 g water into a beaker
- recorded the starting temperature of the water
- heated the water by burning propane for 1 minute
- recorded the temperature of the water after burning the propane.

Table 1 shows the student's results for the investigation.

Table 1

Starting temperature of water in °C	**Temperature of water after burning propane in °C**	**Temperature change of water in °C**
19	34	

2.1 Calculate the temperature change of the water.

[1 mark]

Temperature change = _____ °C

2.2 Calculate the energy released in joules when propane is burned for 1 minute.

Use the equation:

energy released (J) = mass of water (g) × 4.2 × temperature change (°C)

[2 marks]

Energy released = _____ J

3.0 A student investigated the energy released when different metals react with copper sulfate solution.

3.1 What is the independent variable in this investigation?

[1 mark]

_____

3.2 What is the dependent variable in this investigation?

[1 mark]

_____

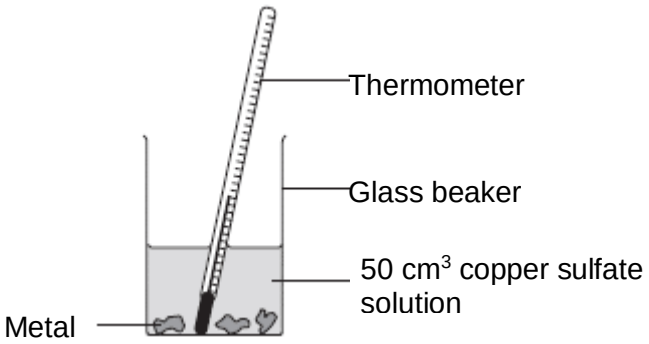
3.3 State **two** control variables the student should keep the same.

[2 marks]

_____

3.4 **Figure 2** shows the equipment the student used for the investigation.

Figure 2



Explain how the student could have improved the **equipment** used for this investigation.

[4 marks]

_____

_____

_____

_____

4.0 Ammonia is used in the manufacture of fertilisers. The equation for the formation of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2) is:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

This question refers to the **forward** reaction which is exothermic.

Bond energies for the reaction are given in **Table 1**.

Table 1

Bond	Bond energy in kJ per mole
N ≡ N	945
H – H	436
N – H	390

The structures are shown in **Figure 1.**

Figure 1

N ≡ N H – H H – N – H (H below N)

4.1 Calculate the overall energy change for the **forward** reaction.

[3 marks]

Overall energy change = _____ J

4.2 Draw an energy level diagram for the **forward** reaction

Mark on the energy level diagram:

- Nitrogen (N_2)
- Hydrogen (H_2)
- Ammonia (NH_3)

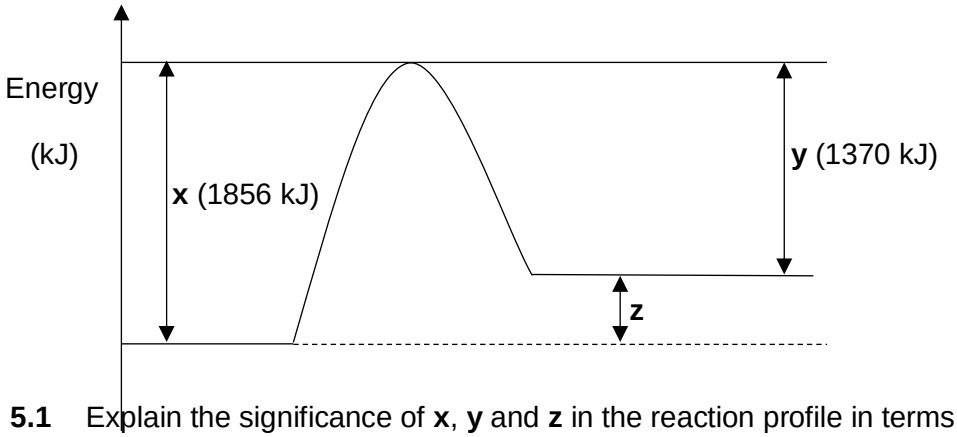
[3 marks]

5.0 Water decomposes to form hydrogen and oxygen.

The equation for the reaction is:

$$2H_2O \rightarrow 2H_2 + O_2$$

The reaction profile for this reaction is shown below.



5.1 Explain the significance of **x**, **y** and **z** in the reaction profile in terms of energy transfers that occur in the reaction.

In your answer make reference to:

- the substances involved
- the bonds broken and formed
- the overall energy transfer

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	any **one** from: • there was a flame • (white) smoke was formed • the magnesium turned into a (white) powder		1
1.2	activation energy		1

Qu No.		Extra Information	Marks
2.1	15 °C		1
2.2	31500 (J)	Allow ecf from 2.1 Allow **1** mark for 500 × 4.2 × 15 or 500 × 4.2 × (ans 2.1)	2

Qu No.		Extra Information	Marks
3.1	Type of metal	Allow metal	1
3.2	Temperature change		1
3.3	Any **two** from: • Volume of copper sulfate solution • Concentration of copper sulfate solution • Mass of metal used • Starting temperature		2
3.4	Used a lid To reduce heat loss or to improve insulation Used a thermometer with a higher resolution. To measure the temperature change more accurately	Allow insulate outside of beaker Allow measure to the nearest 0.5 °C or 0.1 °C	1 1 1 1

Qu No.		Extra Information	Marks
4.1	(energy taken in) =945 + (3 × 436) = 2253 (kJ) (energy given out)= 6 × 390 = 2340 (kJ) (energy change) 2253 – 2340 = (–) 87 (kJ)	 Allow ecf from step 1/ 2 Correct answer with/without working gains **3** marks.	1 1 1
4.2	Reactant energy higher than the product energy Curve for the reaction correctly drawn Nitrogen and hydrogen shown as reactants and ammonia as a product		1 1 1

Qu No.		Extra Information	Marks
5.1			
Level 3:	A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
Substances • reactant is water • products are oxygen and hydrogen significance of x, y and z • x is energy required to break the bonds in reactant / water • x is activation energy • y is the energy released given out when bonds form • y is the energy released given out when hydrogen and oxygen form • z is difference between × and y • z is the overall energy transfer overall energy transfer • z = 1856 – 1370 = (+)486 kJ • overall, energy is absorbed in the reaction • energy required to break existing bonds is greater than the energy released when new bonds form • so reaction is endothermic			

5-5 Energy Changes – Trilogy

1.0 The **Figure 1** shows magnesium burning in air.

Figure 1

© Charles D Winters/Science Photo Library

1.1 Give **one** observation that you can make from **Figure 1** that shows that a chemical reaction is taking place.

[1 mark]

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1.2 The Bunsen burner flame provides energy to start the magnesium burning.

Draw a ring around the name given to the energy needed to start a chemical reaction.

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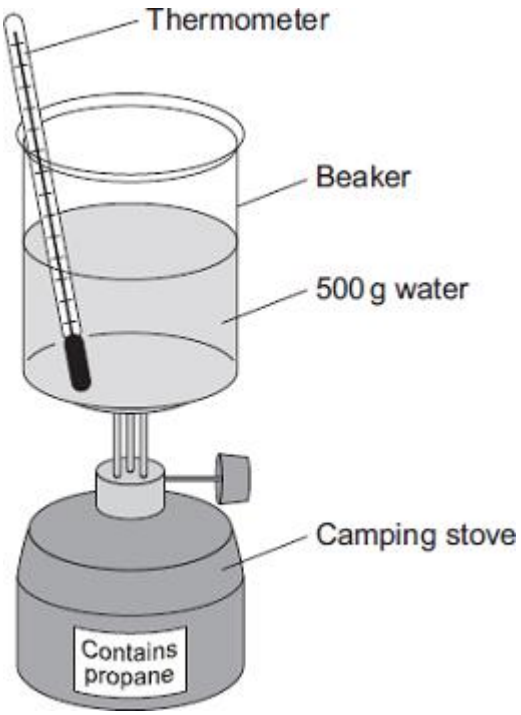

The student:

- put 500 g water into a beaker
- recorded the starting temperature of the water
- heated the water by burning propane for 1 minute
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Table 1 shows the student's results for the investigation.

Table 1

Starting temperature of water in °C	**Temperature of water after burning propane in °C**	**Temperature change of water in °C**
19	34	

2.1 Calculate the temperature change of the water.

[1 mark]

Temperature change = _____ °C

2.2 Calculate the energy released in joules when propane is burned for 1 minute.

Use the equation:

energy released (J) = mass of water (g) × 4.2 × temperature change (°C)

[2 marks]

Energy released = _____ J

3.0 A student investigated the energy released when different metals react with copper sulfate solution.

3.1 What is the independent variable in this investigation?

[1 mark]

_____

3.2 What is the dependent variable in this investigation?

[1 mark]

_____

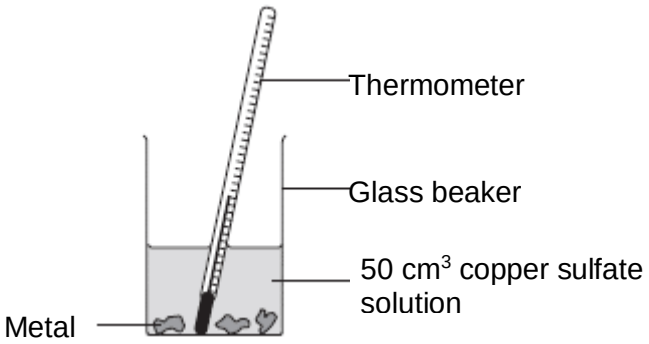
3.3 State **two** control variables the student should keep the same.

[2 marks]

_____

3.4 **Figure 2** shows the equipment the student used for the investigation.

Figure 2



Explain how the student could have improved the **equipment** used for this investigation.

[4 marks]

_____

_____

_____

_____

4.0 Ammonia is used in the manufacture of fertilisers. The equation for the formation of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2) is:

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This question refers to the **forward** reaction which is exothermic.

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The structures are shown in **Figure 1.**

Figure 1

N ≡ N H – H H – N – H (H below N)

4.1 Calculate the overall energy change for the **forward** reaction.

[3 marks]

Overall energy change = _____ J

4.2 Draw an energy level diagram for the **forward** reaction

Mark on the energy level diagram:

- Nitrogen (N_2)
- Hydrogen (H_2)
- Ammonia (NH_3)

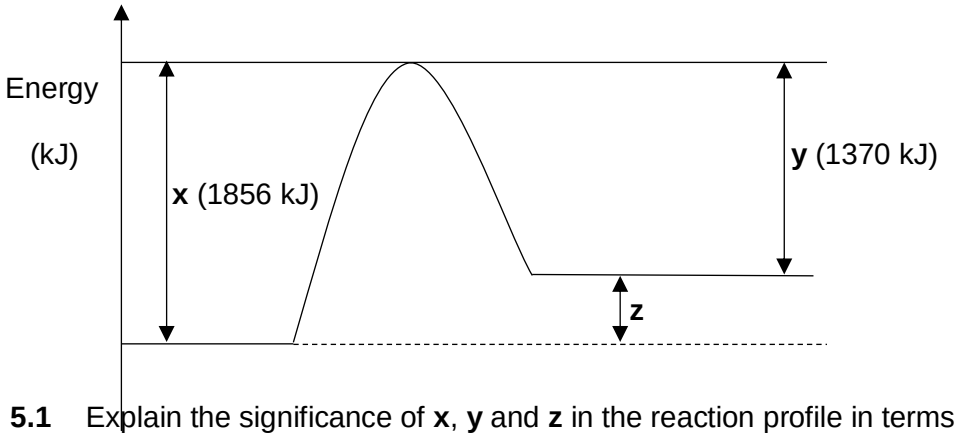
[3 marks]

5.0 Water decomposes to form hydrogen and oxygen.

The equation for the reaction is:

$$2H_2O \rightarrow 2H_2 + O_2$$

The reaction profile for this reaction is shown below.



5.1 Explain the significance of **x**, **y** and **z** in the reaction profile in terms of energy transfers that occur in the reaction.

In your answer make reference to:

- the substances involved
- the bonds broken and formed
- the overall energy transfer

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	any **one** from: • there was a flame • (white) smoke was formed • the magnesium turned into a (white) powder		1
1.2	activation energy		1

Qu No.		Extra Information	Marks
2.1	15 °C		1
2.2	31500 (J)	Allow ecf from 2.1 Allow **1** mark for 500 × 4.2 × 15 or 500 × 4.2 × (ans 2.1)	2

Qu No.		Extra Information	Marks
3.1	Type of metal	Allow metal	1
3.2	Temperature change		1
3.3	Any **two** from: • Volume of copper sulfate solution • Concentration of copper sulfate solution • Mass of metal used • Starting temperature		2
3.4	Used a lid To reduce heat loss or to improve insulation Used a thermometer with a higher resolution. To measure the temperature change more accurately	Allow insulate outside of beaker Allow measure to the nearest 0.5 °C or 0.1 °C	1 1 1 1

Qu No.		Extra Information	Marks
4.1	(energy taken in) =945 + (3 × 436) = 2253 (kJ) (energy given out)= 6 × 390 = 2340 (kJ) (energy change) 2253 – 2340 = (–) 87 (kJ)	 Allow ecf from step 1/ 2 Correct answer with/without working gains **3** marks.	1 1 1
4.2	Reactant energy higher than the product energy Curve for the reaction correctly drawn Nitrogen and hydrogen shown as reactants and ammonia as a product		1 1 1

Qu No.		Extra Information	Marks
5.1			
Level 3:	A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
Substances • reactant is water • products are oxygen and hydrogen significance of x, y and z • x is energy required to break the bonds in reactant / water • x is activation energy • y is the energy released given out when bonds form • y is the energy released given out when hydrogen and oxygen form • z is difference between × and y • z is the overall energy transfer overall energy transfer • z = 1856 – 1370 = (+)486 kJ • overall, energy is absorbed in the reaction • energy required to break existing bonds is greater than the energy released when new bonds form • so reaction is endothermic			

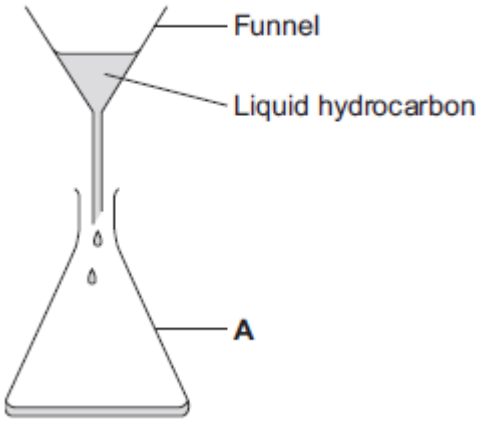
5-7 Organic Chemistry – Trilogy

1.0 A student investigated the viscosity of liquid hydrocarbons.

The student used this method:

1. Measure 40 cm^3 of the liquid hydrocarbon.
2. Pour the liquid hydrocarbon into the funnel.

Figure 1



3. Time how long it takes for all of the liquid hydrocarbon to run out of the funnel.
4. Repeat the experiment for the other liquid hydrocarbons.

1.1 Give the name of apparatus **A** in **Figure 1.**

[1 mark]

_____

1.2 Name the apparatus that could be used to measure 40cm^3 of liquid hydrocarbon.

[1 mark]

_____

The student's results for six liquid hydrocarbons are shown in **Table 1**.

Table 1

Formula of liquid hydrocarbon	Time for liquid hydrocarbon to run out of the funnel in seconds			Mean time in seconds
	Experiment 1	Experiment 2	Experiment 3	
C_6H_{14}	12.2	11.8	12.0	12.0
C_7H_{16}	14.7	15.2	15.4	15.1
C_8H_{18}	18.7	19.9	18.9	
$C_{10}H_{22}$	27.6	26.8	28.2	27.5
$C_{12}H_{26}$	48.3	48.5	48.1	47.4
$C_{14}H_{30}$	65.9	67.1	69.0	67.3

1.3 Explain how the data show that the student's results are **precise**.

[1 mark]

_____

_____

1.4 Describe the pattern shown on **Table 1** between the number of carbon atoms in a molecule of liquid hydrocarbon and the time taken for the liquid hydrocarbon to run out of the funnel.

[1 mark]

_____

_____

1.5 Identify the anomalous result on the table.
Suggest **one** error the student may have made to get this anomalous result.

[2 marks]

Anomalous result: _____

Error: _____

1.6 Use the data in **Table 1** to calculate the mean time in seconds for C_8H_{18}.
Give your answer to an appropriate number of significant figures.

[1 mark]

Mean time = _____s

1.7 Give **one** safety precaution the student should take when carrying out this experiment.

[1 mark]

_____

_____

2.0 This question is about organic molecules.

2.1 Large hydrocarbon molecules can be broken into smaller molecules by heating with a catalyst.
The equation shows **one** example of this type of reaction.

$$C_{11}H_{24} \rightarrow 2C_3H_6 + C_5H_{12}$$

Which word describes this type of reaction?

[1 mark]

Tick **one** box.

Cracking ☐

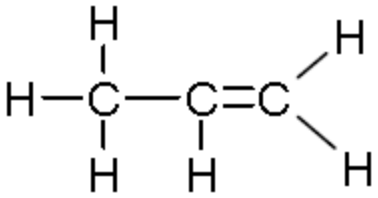
Polymerisation ☐

Precipitation ☐

Reduction ☐

2.2 **Figure 2** shows propene as a displayed structure.

Figure 2



Draw a ring around the part of the molecule which makes propene unsaturated.

[1 mark]

2.3 Bromine water changes colour when mixed with an unsaturated compound like propene.
Complete the sentences.
Use words from the box.

[2 marks]

Blue	**Colourless**	**Green**	**Orange**	**Red**

Before mixing with propene, bromine water is _____.

After mixing with propene, bromine water is _____.

3.1 Which one of the following is **not** an alkane?

[1 mark]

Tick **one** box.

C_8H_{15} ☐

$C_{12}H_{26}$ ☐

$C_{16}H_{34}$ ☐

$C_{24}H_{50}$ ☐

3.2 Which has the **highest** boiling point?

Draw a ring around the correct answer.

[1 mark]

C_3H_6 **C_5H_{12}** **$C_{10}H_{22}$** **C_8H_{18}**

3.3 **Table 2** shows some information about alkanes.

Table 2

Name	Formula	Relative formula mass	Boiling point in °C
methane	CH_4	16	–160
ethane	C_2H_6	30	–90
propane	C_3H_8	44	–40
butane	C_4H_{10}	58	–1
pentane	C_5H_{12}	72	
hexane	C_6H_{14}	86	68

What is the formula of heptane, the next member of the series?

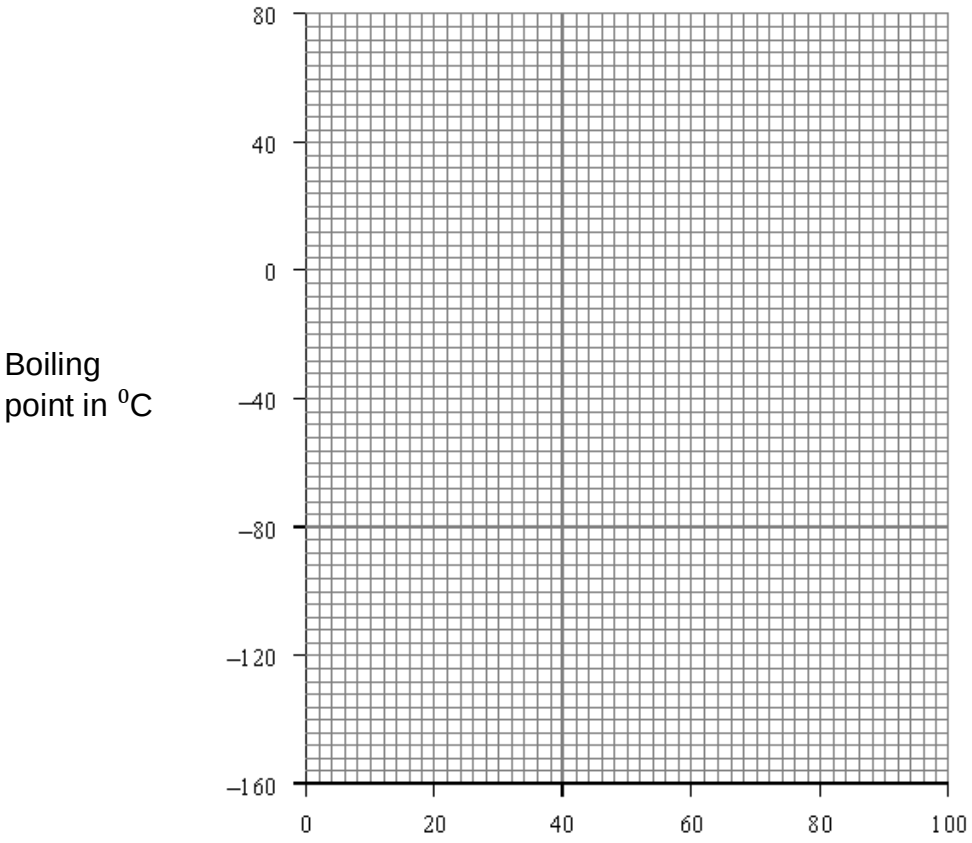
[1 mark]

3.4 Draw a graph of relative formula mass against boiling point.

On the graph:

- plot the points
- draw a line of best fit.

[3 marks]



3.5 Give two conclusions you can make from your graph.

[2 marks]

4.0 Crude oil contains a mixture of hydrocarbons.

The table below shows the relative market demand and available supply of each fraction.

Fraction	Boiling point in °C	Relative % supply in crude oil	Relative % demand
Liquid Petroleum Gas	Less than 30	2	5
Gasoline (petrol)	30-160	15	30
Kerosene (paraffin)	160-250	10	20
Diesel	220-350	20	25
Fuel and Heavy oils	Greater than 350	53	20

4.1 Describe how **fractional distillation** and **cracking** are used so that sufficient petrol is produced from crude oil to meet demand.

Use the information in the table, and your own knowledge.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	(conical) flask		1
1.2	measuring cylinder / pipette / burette		1
1.3	(for each hydrocarbon there is) Little difference from mean between the repeats / little spread about the mean		1
1.4	As the number of carbon atoms increases, the time taken for the hydrocarbon to run out of the funnel increases		1
1.5	C_8H_{18} Trial 2 any **one** from: • longer hydrocarbon used • volume of hydrocarbon too great • started timing early • stopped timing too late	Allow 19.9; or this result circled on table must indicate why the result is **higher** than the others. allow the temperature was lower **or** the students used a thinner funnel.	1 1
1.6	$\frac{18.7 + 18.9}{2}$ 18.8	 An answer of 18.8 without working gains 2 marks Allow 19.2 for one mark	1 1
1.7	Wear safety glasses	allow any suitable safety precaution	1

Qu No.		Extra Information	Marks
2.1	Cracking		1
2.2	Ring drawn around the functional group	Minimum to enclose C=C Must not enclose any of the atoms of the methyl group	1
2.3	Orange Colourless		1 1

Qu No.		Extra Information	Marks
3.1	C_8H_{15}		1
3.2	$C_{10}H_{22}$		1
3.3	C_7H_{16}		1
3.4	All points plotted correctly Best fit straight line	± ½ small square Allow 1 mark for 5/6 plotted correctly	2 1
3.5	As the relative formula mass increases the higher the temperature of the boiling point non-linear/not proportional or change gets smaller as relative formula mass gets higher		1 1

Qu No.		Extra Information	Marks
4.1			
Level 3:	A detailed and coherent description is given for both processes, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	A description is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
Fractional distillation • Crude oil heated / evaporated • Vapours enter column • Vapours condense and are collected at different levels • Each fraction has different boiling / condensing point • Each fraction has different size molecules *Cracking* • Large molecules heated / evaporated / vaporised • Molecules cracked / broken/ decomposed • Passed over hot catalyst at ~450-550°C *or* • Heated with water/steam at ~800-900°C • Smaller molecules are produced • Products contain alkenes and alkanes • Alkenes used for making polymers or alcohols • Alkanes used for fuels			

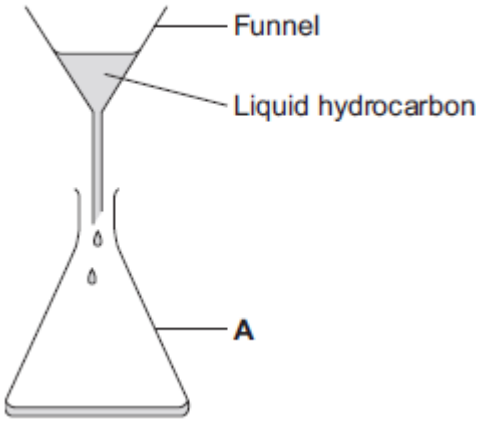
5-7 Organic Chemistry – Trilogy

1.0 A student investigated the viscosity of liquid hydrocarbons.

The student used this method:

1. Measure 40 cm^3 of the liquid hydrocarbon.
2. Pour the liquid hydrocarbon into the funnel.

Figure 1



3. Time how long it takes for all of the liquid hydrocarbon to run out of the funnel.
4. Repeat the experiment for the other liquid hydrocarbons.

1.1 Give the name of apparatus **A** in **Figure 1.**

[1 mark]

_____

1.2 Name the apparatus that could be used to measure 40cm^3 of liquid hydrocarbon.

[1 mark]

_____

The student's results for six liquid hydrocarbons are shown in **Table 1**.

Table 1

Formula of liquid hydrocarbon	Time for liquid hydrocarbon to run out of the funnel in seconds			Mean time in seconds
	Experiment 1	Experiment 2	Experiment 3	
C_6H_{14}	12.2	11.8	12.0	12.0
C_7H_{16}	14.7	15.2	15.4	15.1
C_8H_{18}	18.7	19.9	18.9	
$C_{10}H_{22}$	27.6	26.8	28.2	27.5
$C_{12}H_{26}$	48.3	48.5	48.1	47.4
$C_{14}H_{30}$	65.9	67.1	69.0	67.3

1.3 Explain how the data show that the student's results are **precise**.

[1 mark]

_____

_____

1.4 Describe the pattern shown on **Table 1** between the number of carbon atoms in a molecule of liquid hydrocarbon and the time taken for the liquid hydrocarbon to run out of the funnel.

[1 mark]

_____

_____

1.5 Identify the anomalous result on the table.
Suggest **one** error the student may have made to get this anomalous result.

[2 marks]

Anomalous result: _____

Error: _____

1.6 Use the data in **Table 1** to calculate the mean time in seconds for C_8H_{18}.
Give your answer to an appropriate number of significant figures.

[1 mark]

Mean time = _____s

1.7 Give **one** safety precaution the student should take when carrying out this experiment.

[1 mark]

_____

_____

2.0 This question is about organic molecules.

2.1 Large hydrocarbon molecules can be broken into smaller molecules by heating with a catalyst.
The equation shows **one** example of this type of reaction.

$$C_{11}H_{24} \rightarrow 2C_3H_6 + C_5H_{12}$$

Which word describes this type of reaction?

[1 mark]

Tick **one** box.

Cracking ☐

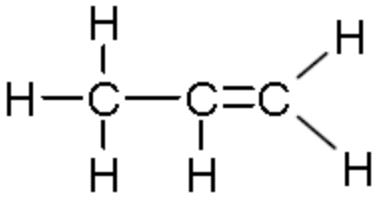
Polymerisation ☐

Precipitation ☐

Reduction ☐

2.2 **Figure 2** shows propene as a displayed structure.

Figure 2



Draw a ring around the part of the molecule which makes propene unsaturated.

[1 mark]

2.3 Bromine water changes colour when mixed with an unsaturated compound like propene.
Complete the sentences.
Use words from the box.

[2 marks]

Blue	**Colourless**	**Green**	**Orange**	**Red**

Before mixing with propene, bromine water is _____.

After mixing with propene, bromine water is _____.

3.1 Which one of the following is **not** an alkane?

[1 mark]

Tick **one** box.

C_8H_{15} ☐

$C_{12}H_{26}$ ☐

$C_{16}H_{34}$ ☐

$C_{24}H_{50}$ ☐

3.2 Which has the **highest** boiling point?

Draw a ring around the correct answer.

[1 mark]

C_3H_6 **C_5H_{12}** **$C_{10}H_{22}$** **C_8H_{18}**

3.3 **Table 2** shows some information about alkanes.

Table 2

Name	Formula	Relative formula mass	Boiling point in °C
methane	CH_4	16	–160
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pentane	C_5H_{12}	72	
hexane	C_6H_{14}	86	68

What is the formula of heptane, the next member of the series?

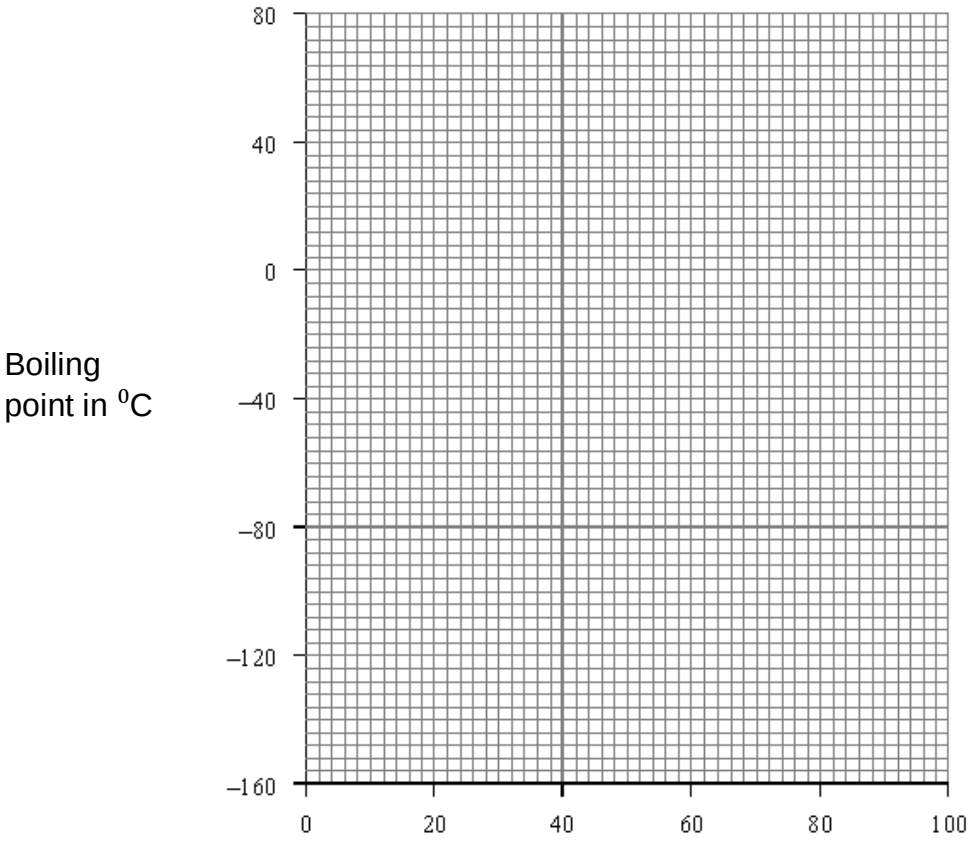
[1 mark]

3.4 Draw a graph of relative formula mass against boiling point.

On the graph:

- plot the points
- draw a line of best fit.

[3 marks]



3.5 Give two conclusions you can make from your graph.

[2 marks]

4.0 Crude oil contains a mixture of hydrocarbons.

The table below shows the relative market demand and available supply of each fraction.

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Diesel	220-350	20	25
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4.1 Describe how **fractional distillation** and **cracking** are used so that sufficient petrol is produced from crude oil to meet demand.

Use the information in the table, and your own knowledge.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	(conical) flask		1
1.2	measuring cylinder / pipette / burette		1
1.3	(for each hydrocarbon there is) Little difference from mean between the repeats / little spread about the mean		1
1.4	As the number of carbon atoms increases, the time taken for the hydrocarbon to run out of the funnel increases		1
1.5	C_8H_{18} Trial 2 any **one** from: • longer hydrocarbon used • volume of hydrocarbon too great • started timing early • stopped timing too late	Allow 19.9; or this result circled on table must indicate why the result is **higher** than the others. allow the temperature was lower **or** the students used a thinner funnel.	1 1
1.6	$\frac{18.7 + 18.9}{2}$ 18.8	 An answer of 18.8 without working gains 2 marks Allow 19.2 for one mark	1 1
1.7	Wear safety glasses	allow any suitable safety precaution	1

Qu No.		Extra Information	Marks
2.1	Cracking		1
2.2	Ring drawn around the functional group	Minimum to enclose C=C Must not enclose any of the atoms of the methyl group	1
2.3	Orange Colourless		1 1

Qu No.		Extra Information	Marks
3.1	C_8H_{15}		1
3.2	$C_{10}H_{22}$		1
3.3	C_7H_{16}		1
3.4	All points plotted correctly Best fit straight line	± ½ small square Allow 1 mark for 5/6 plotted correctly	2 1
3.5	As the relative formula mass increases the higher the temperature of the boiling point non-linear/not proportional or change gets smaller as relative formula mass gets higher		1 1

Qu No.		Extra Information	Marks
4.1			
Level 3:	A detailed and coherent description is given for both processes, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	A description is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
Fractional distillation • Crude oil heated / evaporated • Vapours enter column • Vapours condense and are collected at different levels • Each fraction has different boiling / condensing point • Each fraction has different size molecules *Cracking* • Large molecules heated / evaporated / vaporised • Molecules cracked / broken/ decomposed • Passed over hot catalyst at ~450-550°C *or* • Heated with water/steam at ~800-900°C • Smaller molecules are produced • Products contain alkenes and alkanes • Alkenes used for making polymers or alcohols • Alkanes used for fuels			

5-3 Quantitative chemistry – Trilogy

1.0 This question is about carbonates.

1.1 Sodium carbonate, Na_2CO_3, is used as a water softener.
Give the number of atoms of each type in sodium carbonate.

[3 marks]

Sodium (Na) atom(s): _____

Carbon (C) atom(s): _____

Oxygen (O) atom(s): _____

1.2 Calculate the relative formula mass (M_r) of sodium carbonate, Na_2CO_3
Relative atomic masses (A_r): Na = 23; C = 12; O = 16.

[2 marks]

Relative formula mass (M_r) of sodium carbonate =_____

1.3 A student heated a sample of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

This is an example of thermal decomposition.
What is meant by 'thermal decomposition'?

[2 marks]

_____

_____

1.4 Both calcium carbonate and calcium oxide are white solids.
The student weighed the white solid before and after heating.
Explain why a decrease in mass was observed.
Use the equation in **part 1.3** to help you answer the question.

[2 marks]

_____

_____

1.5 One type of copper ore is mainly copper carbonate. When producing copper, the ore reacts with carbon.

copper carbonate	**+ carbon**	→	**copper**	**+ carbon dioxide**
____ tonnes	24 tonnes		254 tonnes	264 tonnes

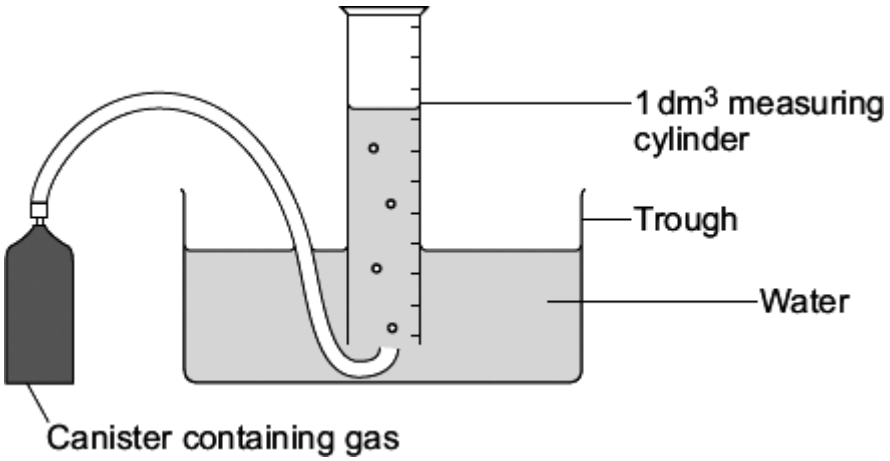
Calculate the mass of copper carbonate needed to produce 254 tonnes of copper.

[2 marks]

Mass = _____ tonnes

2.0 A student did an experiment to find the relative formula mass (M_r) of a gas.
The equipment used is shown in **Figure 1**

Figure 1



The student:

- measured the mass of the canister of gas
- filled the measuring cylinder with 1 dm^3 of the gas from the canister
- measured the mass of the canister of gas again
- measured the temperature of the laboratory
- measured the air pressure in the laboratory
- repeated the experiment.

2.1 The student calculated values for the relative formula mass (M_r) of the gas.
The results are shown in the table below.

Experiment	**1**	**2**	**3**	**4**
Relative formula mass (M_r)	45.4	51.5	46.3	45.8

Calculate the mean value for these results.
Give your answer to 3 significant figures.

[2 marks]

Mean = _____

2.2 The experiments gave different results for the relative formula mass of the gas. This was caused by experimental error.
Suggest **one** experimental error that the student may have made.

[1 mark]

_____

2.3 Give **one** reasons why it is important to repeat the experiment.

[1 mark]

_____

_____

3.0 A student investigated the thermal decomposition of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

The relative formula masses (M_r) are: $CaCO_3$ = 100**;** CaO = 56; CO_2 = 44

Describe how this experiment could be used to provide evidence for the law of conservation of mass.
Include in your answer:

- The method
- Which measurements should be taken
- How the student could show evidence for conservation of mass

[6 marks]

_____

_____

_____

_____

_____

_____

_____

4.0 A student made some copper sulfate crystals, $CuSO_4$.
The student used 7.95 g of copper oxide and 100 cm^3 of a 2.00 mol/dm^3 solution of sulfuric acid.
The equation for the reaction is:

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$

4.1 Calculate the number of moles of copper oxide in 7.95 g copper oxide.
Relative atomic masses A_r: O = 16; Cu = 63.5

[2 marks]

Answer = _____ moles

4.2 Calculate the number of moles of sulfuric acid in 100 cm^3 of 2.00 mol/dm^3 sulfuric acid.

[2 marks]

Answer = _____ moles

4.3 It is common to use an excess of one reactant.
Explain why a reactant is used in excess.

[2 marks]

_____

_____

4.4 Another student made copper sulfate using 0.250 moles of copper oxide and 0.500 moles of sulfuric acid.
Calculate the **maximum** mass of copper sulfate which could be produced.
Give your answer to 3 significant figures.
Relative formula mass (M_r) $CuSO_4$ = 159.5

[4 marks]

Maximum mass of copper sulfate = _____ g

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	2 1 3	In this order	 1 1 1
1.2	(2 x 23) + 12 + (3 x 16) **or** 46 + 12 + 48 106	 An answer of 106 without any working shown gains **2** marks	1 1
1.3	Breaking down Using heat		1 1
1.4	Carbon dioxide is produced which goes into the atmosphere	Allow a gas is produced	1 1
1.5	(254 + 264) − 24 **or** 518 – 24 494 (tonnes)	 An answer of 494 (tonnes) without any working shown gains **2** marks	1 1

Qu No.		Extra Information	Marks
2.1	(45.4 + 46.3 + 45.8) ÷ 3 45.8	Allow 46 or 45.83(33…) Allow 47.3 Allow **2** marks for an answer of 45.8 without working	1 1
2.2	Any **one** from: • Loss of gas or leak • Error in measurement of volume of gas • Error in weighing the canister / gas at start • Error in weighing the canister / gas at end • Change in temperature • Change in pressure	 Allow incorrect measurement of temperature Allow incorrect measurement of pressure	1
2.3	Any **one** from: • To check for anomalous results • To find the mean	 Allow to find the average	1

Qu No.		Extra Information	Marks
3.0			
Level 3:	A coherent method is described and explained with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered and would lead to the production of valid results. An explanation of the expected results is provided.		5–6
Level 2:	The bulk of a 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. An attempted explanation of the expected results is given.		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
	No relevant content		0
Indicative content			
Method • Measure mass of suitable container eg boiling tube • Mass measured using balance • Place calcium carbonate in boiling tube • Measure mass of boiling tube and calcium carbonate • Heat boiling tube and calcium carbonate • Allow to cool • Reweigh tube and contents • Repeat heating, cooling and weighing until constant mass is obtained Conservation of mass • Identifies the conservation of mass • Carbon dioxide produced as a gas • Carbon dioxide escapes to the surroundings • So mass will decrease during the reaction • Suggests initial mass to be heated • Use the initial mass to suggest final mass in boiling tube • Use suggested masses to confirm law of conservation of mass			

Qu No.		Extra Information	Marks
4.1	$\frac{7.95}{16+63.5}$ or $\frac{7.95}{79.5}$ 0.1 (moles)	 Allow **2** marks for an answer of 0.1 (moles) without working	1 1
4.2	$\frac{100}{1000}$ × 2 0.2 (moles)	 Allow **2** marks for an answer of 0.2 (moles) without working	1 1
4.3	(So that) the other reactant is completely used up		1 1
4.4	Evidence of sulfuric acid in excess or Copper oxide limiting reagent Moles of copper sulfate = moles of copper oxide = 0.250 (Mass of copper sulfate =) 0.25 x 159.5 39.9 (g)	 Allow ecf for steps 2/3/4 Allow **4** marks for an answer of 0.2 (moles) without working	1 1 1 1

5-3 Quantitative chemistry – Trilogy

1.0 This question is about carbonates.

1.1 Sodium carbonate, Na_2CO_3, is used as a water softener.
Give the number of atoms of each type in sodium carbonate.

[3 marks]

Sodium (Na) atom(s): _____

Carbon (C) atom(s): _____

Oxygen (O) atom(s): _____

1.2 Calculate the relative formula mass (M_r) of sodium carbonate, Na_2CO_3
Relative atomic masses (A_r): Na = 23; C = 12; O = 16.

[2 marks]

Relative formula mass (M_r) of sodium carbonate =_____

1.3 A student heated a sample of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

This is an example of thermal decomposition.
What is meant by 'thermal decomposition'?

[2 marks]

_____

_____

1.4 Both calcium carbonate and calcium oxide are white solids.
The student weighed the white solid before and after heating.
Explain why a decrease in mass was observed.
Use the equation in **part 1.3** to help you answer the question.

[2 marks]

_____

_____

1.5 One type of copper ore is mainly copper carbonate. When producing copper, the ore reacts with carbon.

copper carbonate	**+ carbon**	→	**copper**	**+ carbon dioxide**
____ tonnes	24 tonnes		254 tonnes	264 tonnes

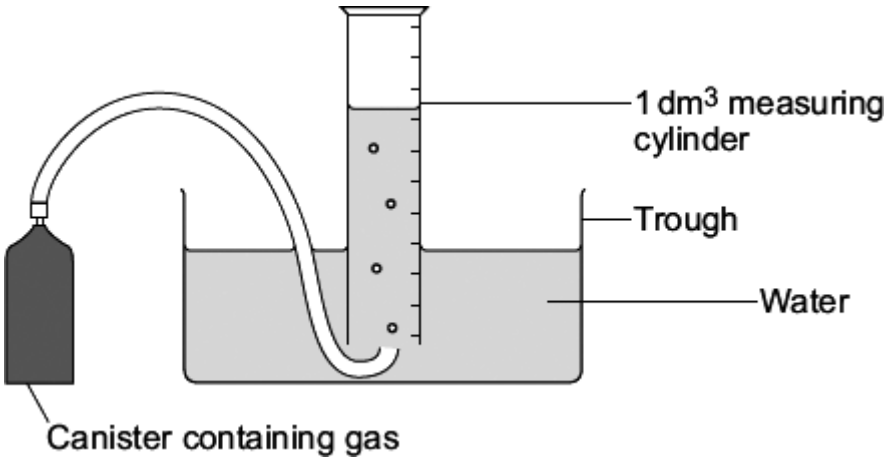
Calculate the mass of copper carbonate needed to produce 254 tonnes of copper.

[2 marks]

Mass = _____ tonnes

2.0 A student did an experiment to find the relative formula mass (M_r) of a gas.
The equipment used is shown in **Figure 1**

Figure 1



The student:

- measured the mass of the canister of gas
- filled the measuring cylinder with 1 dm^3 of the gas from the canister
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- measured the temperature of the laboratory
- measured the air pressure in the laboratory
- repeated the experiment.

2.1 The student calculated values for the relative formula mass (M_r) of the gas.
The results are shown in the table below.

Experiment	**1**	**2**	**3**	**4**
Relative formula mass (M_r)	45.4	51.5	46.3	45.8

Calculate the mean value for these results.
Give your answer to 3 significant figures.

[2 marks]

Mean = _____

2.2 The experiments gave different results for the relative formula mass of the gas. This was caused by experimental error.
Suggest **one** experimental error that the student may have made.

[1 mark]

_____

2.3 Give **one** reasons why it is important to repeat the experiment.

[1 mark]

_____

_____

3.0 A student investigated the thermal decomposition of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

The relative formula masses (M_r) are: $CaCO_3$ = 100**;** CaO = 56; CO_2 = 44

Describe how this experiment could be used to provide evidence for the law of conservation of mass.
Include in your answer:

- The method
- Which measurements should be taken
- How the student could show evidence for conservation of mass

[6 marks]

_____

_____

_____

_____

_____

_____

_____

4.0 A student made some copper sulfate crystals, $CuSO_4$.
The student used 7.95 g of copper oxide and 100 cm^3 of a 2.00 mol/dm^3 solution of sulfuric acid.
The equation for the reaction is:

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$

4.1 Calculate the number of moles of copper oxide in 7.95 g copper oxide.
Relative atomic masses A_r: O = 16; Cu = 63.5

[2 marks]

Answer = _____ moles

4.2 Calculate the number of moles of sulfuric acid in 100 cm^3 of 2.00 mol/dm^3 sulfuric acid.

[2 marks]

Answer = _____ moles

4.3 It is common to use an excess of one reactant.
Explain why a reactant is used in excess.

[2 marks]

_____

_____

4.4 Another student made copper sulfate using 0.250 moles of copper oxide and 0.500 moles of sulfuric acid.
Calculate the **maximum** mass of copper sulfate which could be produced.
Give your answer to 3 significant figures.
Relative formula mass (M_r) $CuSO_4$ = 159.5

[4 marks]

Maximum mass of copper sulfate = _____ g

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	2 1 3	In this order	 1 1 1
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1.5	(254 + 264) − 24 **or** 518 – 24 494 (tonnes)	 An answer of 494 (tonnes) without any working shown gains **2** marks	1 1

Qu No.		Extra Information	Marks
2.1	(45.4 + 46.3 + 45.8) ÷ 3 45.8	Allow 46 or 45.83(33…) Allow 47.3 Allow **2** marks for an answer of 45.8 without working	1 1
2.2	Any **one** from: • Loss of gas or leak • Error in measurement of volume of gas • Error in weighing the canister / gas at start • Error in weighing the canister / gas at end • Change in temperature • Change in pressure	 Allow incorrect measurement of temperature Allow incorrect measurement of pressure	1
2.3	Any **one** from: • To check for anomalous results • To find the mean	 Allow to find the average	1

Qu No.		Extra Information	Marks
3.0			
Level 3:	A coherent method is described and explained with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered and would lead to the production of valid results. An explanation of the expected results is provided.		5–6
Level 2:	The bulk of a 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. An attempted explanation of the expected results is given.		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
	No relevant content		0
Indicative content			
Method • Measure mass of suitable container eg boiling tube • Mass measured using balance • Place calcium carbonate in boiling tube • Measure mass of boiling tube and calcium carbonate • Heat boiling tube and calcium carbonate • Allow to cool • Reweigh tube and contents • Repeat heating, cooling and weighing until constant mass is obtained Conservation of mass • Identifies the conservation of mass • Carbon dioxide produced as a gas • Carbon dioxide escapes to the surroundings • So mass will decrease during the reaction • Suggests initial mass to be heated • Use the initial mass to suggest final mass in boiling tube • Use suggested masses to confirm law of conservation of mass			

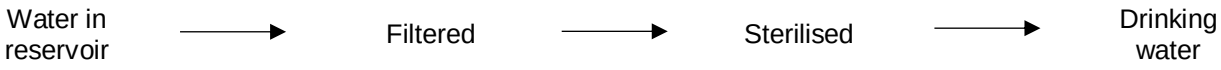
Qu No.		Extra Information	Marks
4.1	$\frac{7.95}{16+63.5}$ or $\frac{7.95}{79.5}$ 0.1 (moles)	 Allow **2** marks for an answer of 0.1 (moles) without working	1 1
4.2	$\frac{100}{1000}$ × 2 0.2 (moles)	 Allow **2** marks for an answer of 0.2 (moles) without working	1 1
4.3	(So that) the other reactant is completely used up		1 1
4.4	Evidence of sulfuric acid in excess or Copper oxide limiting reagent Moles of copper sulfate = moles of copper oxide = 0.250 (Mass of copper sulfate =) 0.25 x 159.5 39.9 (g)	 Allow ecf for steps 2/3/4 Allow **4** marks for an answer of 0.2 (moles) without working	1 1 1 1

5-10 Using resources – Trilogy

1.0 This question is about water.

Water from reservoirs needs to be treated before it is safe to drink.

The flow diagram below shows how water is made suitable for drinking.



1.1 What is removed when the water is filtered?

[1 mark]

Tick **one** box.

- Bacteria ☐
- Solids ☐
- Solutions ☐
- Toxic substances ☐

1.2 Which **two** substances which can be used to sterilise water?

[2 marks]

Tick **two** boxes.

- Chlorine ☐
- Oxygen ☐
- Ozone ☐
- Salt ☐
- Sand ☐

1.3 Give **one** reason why drinking water is sterilised.

[1 mark]

_____

_____

1.4 Sea water is **not** suitable for drinking.

Suggest **one** reason why.

[1 mark]

_____

_____

2.0 Suggest **three** reasons why metals such as copper should **not** be disposed of in landfill sites.

[3 marks]

3.0 Desalination of seawater can be carried out by processes that use membranes such as reverse osmosis.

3.1 Describe one **other** way to desalinate sea water in a school laboratory.

You may include a labelled diagram in your answer.

[4 marks]

3.2 A student investigated how much solid was dissolved in sea water.

The student:

1. Measured the mass of an empty evaporating basin.
2. Measured 50 cm^3 of sea water and poured it into the evaporating basin.
3. Heated the evaporating basin gently until all of the water had evaporated.
4. Measured the mass of the evaporating basin containing the solid residue.
5. Reheated the evaporating basin and solid residue.
6. Measured the mass of the evaporating basin and solid residue.
7. Repeated steps 5 and 6 until the mass was constant.

Name two different pieces of apparatus that would be suitable for measuring:

- The mass of the evaporating basin
- 50 cm^3 of sea water

[2 marks]

Equipment to measure the mass of the evaporating basin_____

Equipment to measure 50 cm^3 of sea water _____

3.3 Why did the student keep reheating the evaporating basin and solid residue until a constant mass was obtained?

[1 mark]

_____

_____

3.4 The results the student obtained using 50 cm^3 of sea water are:

Mass of empty evaporating basin = 23.57 g
Mass of evaporating basin and dry solid residue = 25.23 g

Calculate the mass of solid dissolved in **1000 cm^3** of the sea water.

[1 mark]

Mass dissolved in 1000 cm^3 = _____ g

4.1 What does 'potable water' mean?

[1 mark]

_____

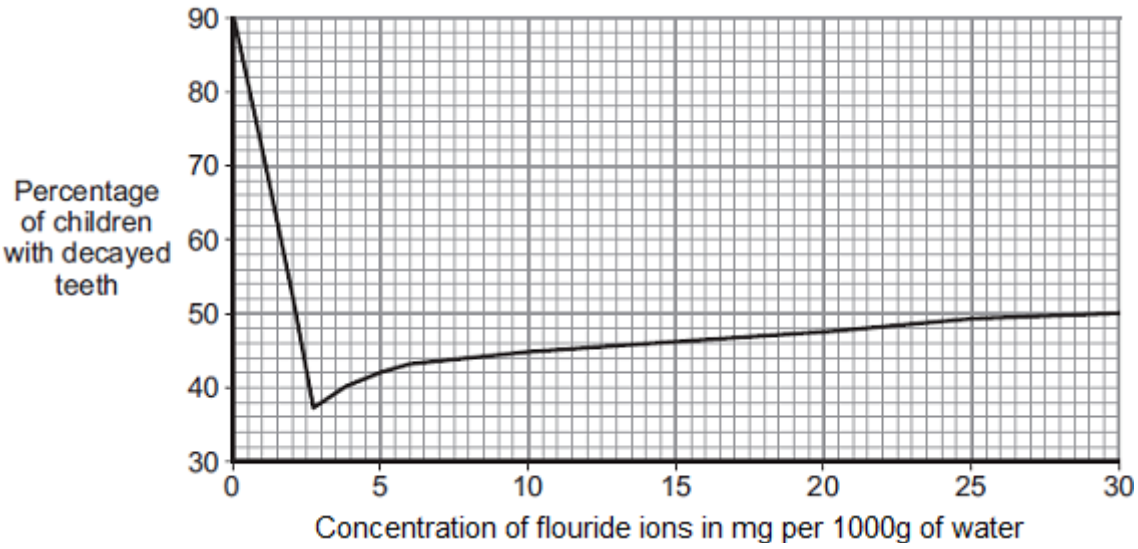
_____

4.2 Compounds containing fluoride ions are added to some drinking water supplies.

Scientists investigated the effect of fluoride ions on tooth decay.

Graph 1 shows the concentration of fluoride ions against the percentage of children with decayed teeth.

Graph 1



Suggest the best concentration of fluoride ions to use in drinking water. Give one reason for your answer.

[2 marks]

Best concentration = _____ mg per 1000g water

Reason:_____

_____

_____

4.3 Describe two patterns shown by **Graph 1**.

[2 marks]

5.0 This question is about extracting metals.

5.1 Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the process is:

$$Cu_2S(s) + O_2(g) \longrightarrow 2\ Cu(s) + SO_2(g)$$

Explain why the gaseous product should not be released into the atmosphere.

[2 marks]

5.2 Describe how copper compounds are obtained by phytomining.

[2 marks]

5.3 Aluminium is extracted from an ore, called bauxite, by electrolysis of molten aluminium oxide.

Aluminium is also widely recycled and the metal is obtained from the recycling process.

Use your knowledge and understanding to compare these methods of producing aluminium.

Your answer should include

- The energy requirement;
- Availability of resources;
- Purity of the products.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	Solids		1
1.2	Chlorine Ozone		1 1
1.3	To kill microbes / bacteria	Allow to make the water safe to drink	1
1.4	Contains (large amounts of) dissolved solids	Allow salty Allow makes you thirsty / vomit Allow polluted / untreated / contaminated	1

Qu No.		Extra Information	Marks
2.0	Any **three** from: • Copper ores are limited / running out • Copper can be recycled / reused • Copper is expensive • Landfill sites are filling up • Copper compounds are toxic	Ignore not biodegradable or does not decay	3

Qu No.		Extra Information	Marks
3.1	Distillation Heat a flask (containing sea water) until it boils Use of a condenser / delivery tube Collect (pure water) in a boiling tube / beaker / flask	 Allow evaporate sea water The last three marks can be obtained from a suitably labelled diagram	1 1 1 1
3.2	(Top pan) balance Measuring cylinder		1 1
3.3	To make sure that all of the water had evaporated		1
3.4	33.2 (g)		1

Qu No.		Extra Information	Marks
4.1	Fit/safe to drink		1
4.2	2.75 (mg per 1000 g of water) As this has the greatest effect on tooth decay	Allow answers in range 2.5 – 3.0 Allow lowest rate of tooth decay	1 1
4.3	As the percentage of fluoride ions increases the number of children with tooth decay decreases until the fluoride ion concentration is 2.75 (mg per 1000 g of water) After a fluoride ion concentration of 2.75 (mg per 1000 g of water), the number of children with tooth decay increases as the fluoride ion concentration increases	Allow ecf in value from 3.5 Allow as the percentage of fluoride ions increases initially the number of children with tooth decay decreases	1 1

Qu No.		Extra Information	Marks
5.1	Sulfur dioxide is an environmental pollutant causing acid rain		1 1
5.2	Grow plants on land containing copper ores, then burn the plants Ash (from burning) contains copper compounds		1 1
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Level 3:	A detailed and coherent comparison is given, which demonstrates a broad knowledge and understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
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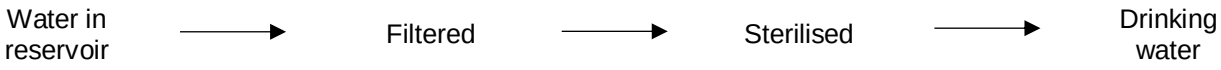

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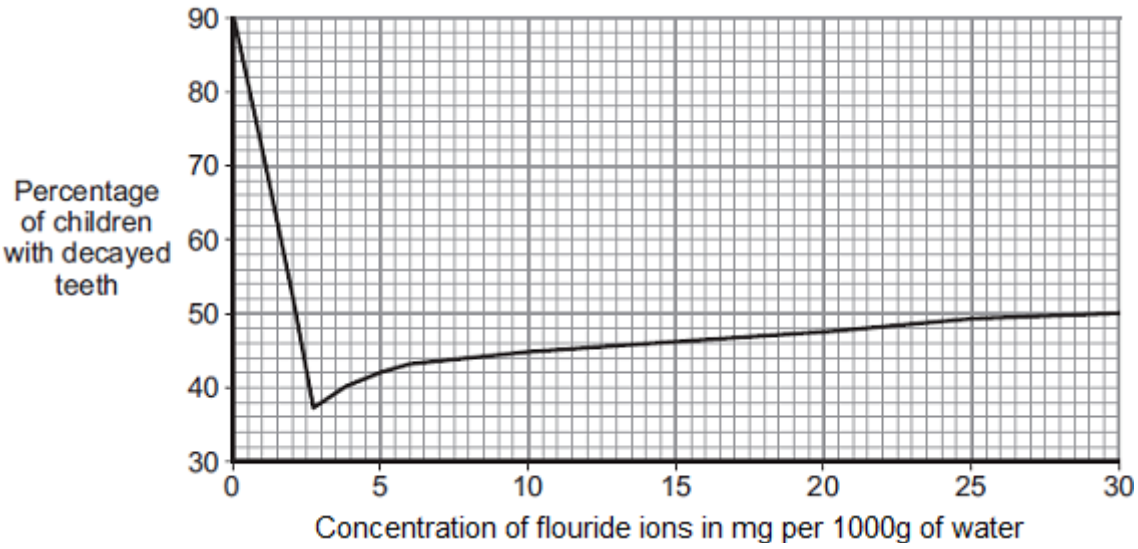

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Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

GCSE
COMBINED SCIENCE: TRILOGY

F

Foundation Tier — Chemistry Paper 1F

Specimen 2018 (set 2) — Time allowed: 1 hour 15 minutes

Materials
For this paper you must have:
- a ruler
- a scientific calculator
- the periodic table (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

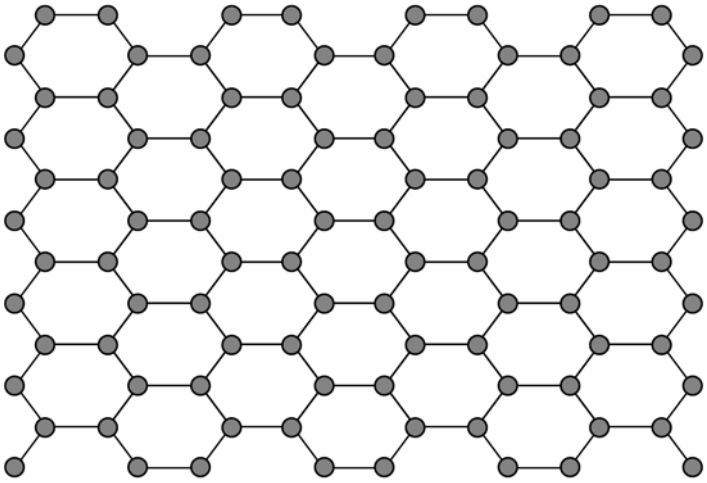
Information
- The maximum mark for this paper is 70.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

0 1 This question is about structure and bonding.

0 1 . 1 **Figure 1** shows part of one layer of graphene.

Figure 1



Which element is graphene made from?

[1 mark]

Tick **one** box.

Carbon ☐

Copper ☐

Hydrogen ☐

Sodium ☐

0 1 . 2 Each atom in graphene has one delocalised electron.

Complete the sentence.

Choose the answer from the box.

[1 mark]

act as a lubricant	**be used as a fuel**
conduct electricity	**dissolve in water**

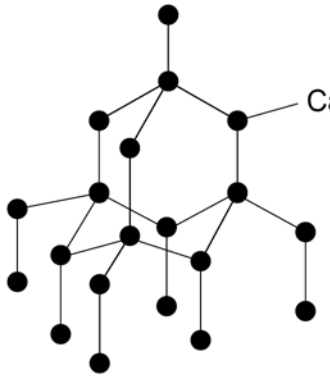
Delocalised electrons allow graphene to _____ .

Question 1 continues on the next page

0 1 . 3 Which structure is a fullerene?

[1 mark]

Tick **one** box.



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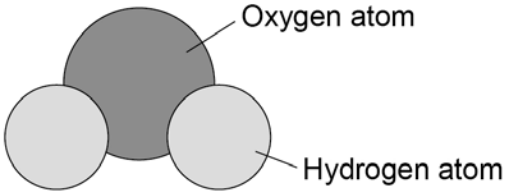

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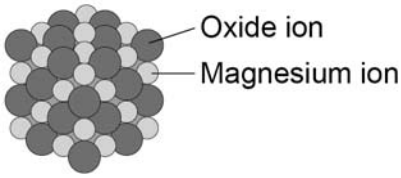

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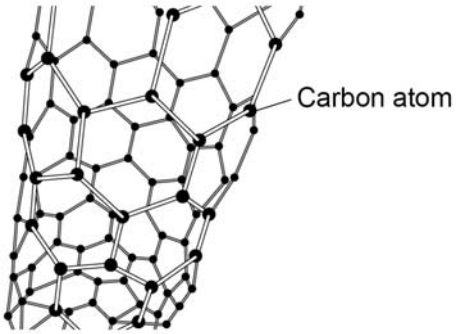
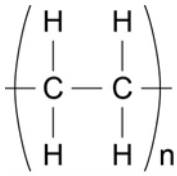


☐

Figure 2 shows part of a large hydrocarbon molecule.

Figure 2



0 1 . 4 Which **two** elements are in all hydrocarbons?

[2 marks]

1 _____

2 _____

0 1 . 5 Complete the sentence.

Choose the answer from the box.

[1 mark]

an atom	**an metal**	**a polymer**	**a salt**

The large molecule represented in **Figure 2** is _____ .

0 1 . 6 Complete the sentence.

Choose the answer from the box.

[1 mark]

attract	**bond**	**slide**	**vibrate**

Metals can be stretched into wires

because the layers of atoms can _____ .

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 2 This question is about electrolysis.

0 2 . 1 How many different elements are in the formula $AgNO_3$?

[1 mark]

Tick **one** box.

2 ☐ 3 ☐ 5 ☐ 6 ☐

0 2 . 2 How many atoms are in the formula $AgNO_3$?

[1 mark]

Tick **one** box.

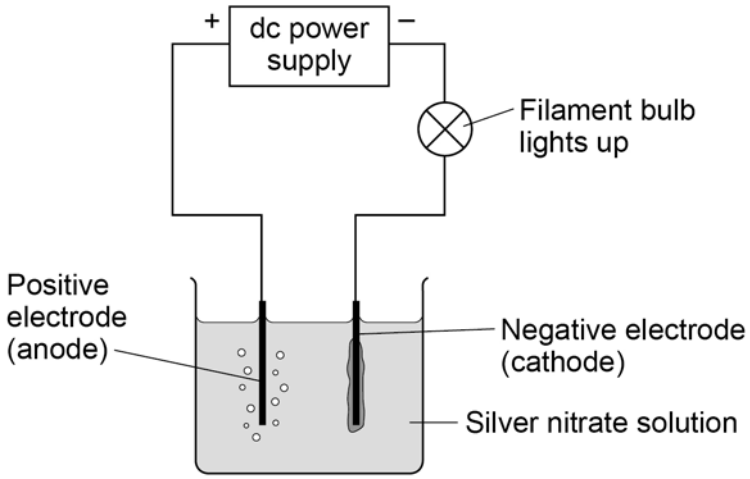
2 ☐ 3 ☐ 5 ☐ 6 ☐

Question 2 continues on the next page

An electric current is passed through silver nitrate solution.

Figure 3 shows the apparatus.

Figure 3



The solution contains four ions:

- Ag^+
- H^+
- NO_3^-
- OH^-

0 2 . 3 Where do the H^+ and OH^- ions come from?

[1 mark]

Tick **one** box.

Air ☐

Electrodes ☐

Silver nitrate ☐

Water ☐

0 2 . 4 Ag^+ ions and H^+ ions are attracted to the negative electrode (cathode).

Give a reason why.

[1 mark]

0 2 . 5 Silver is produced at the negative electrode (cathode) and not hydrogen.

What does this tell you about the reactivity of silver?

[1 mark]

Tick **one** box.

Silver is less reactive than hydrogen ☐

Silver is less reactive than oxygen ☐

Silver is more reactive than nitrate ☐

Silver is more reactive than water. ☐

0 2 . 6 The hydroxide ion (OH^-) is attracted to the positive electrode (anode).

The equation shows what happens at the positive electrode (anode).

$$4\,OH^- \rightarrow 2\,H_2O + O_2 + 4\,e^-$$

Name the gas produced at the positive electrode (anode).

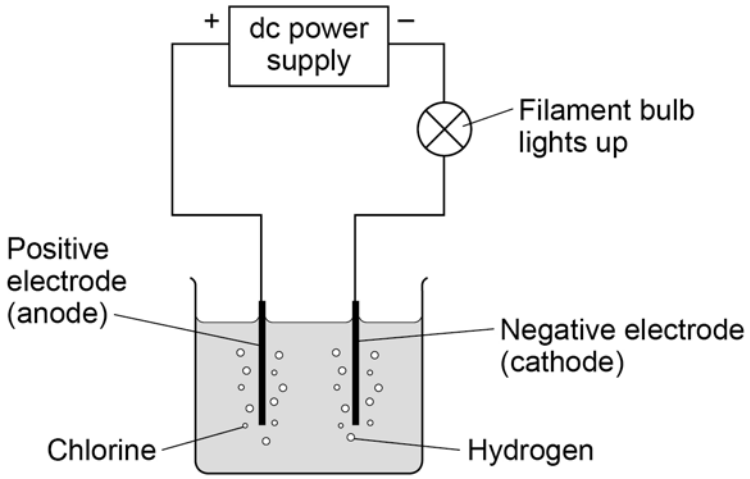
[1 mark]

Question 2 continues on the next page

0 2 . 7 An electric current is passed through sodium chloride solution.

Figure 4 shows the apparatus.

Figure 4



After passing an electric current through sodium chloride solution one product is sodium hydroxide (NaOH) solution.

The presence of sodium hydroxide can be shown by adding an indicator.

Name an indicator.

Give the colour of the indicator in sodium hydroxide solution.

[2 marks]

Indicator _____

Colour _____

8

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 3 This question is about compounds of fluorine.

0 3 . 1 A fluorine atom has 7 electrons in the outer shell.

Figure 5 shows part of a dot and cross diagram of a molecule of hydrogen fluoride (HF).

Complete the dot and cross diagram in **Figure 5**.

You should show only the electrons in the outer shells.

[2 marks]

Figure 5

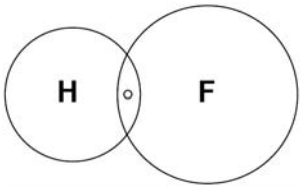
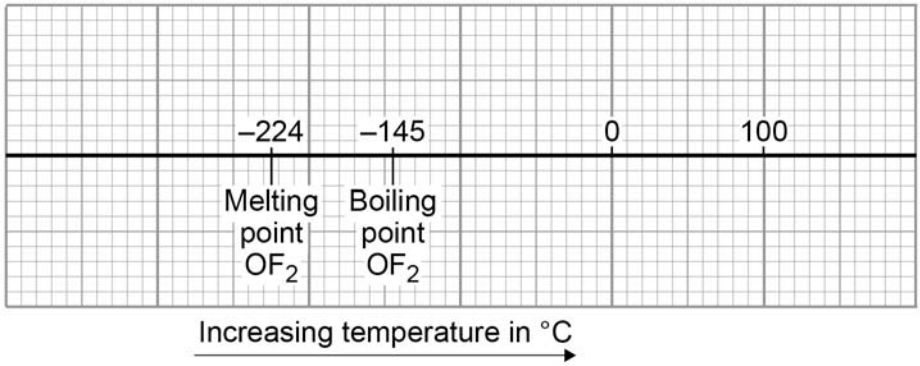


Figure 6 shows the boiling point and melting point of oxygen difluoride (OF_2).

Figure 6



0 3 . 2 What is the state of oxygen difluoride at −200 °C?

[1 mark]

Tick **one** box.

Aqueous (aq) ☐

Gas (g) ☐

Liquid (l) ☐

Solid (s) ☐

0 3 . 3 What change of state occurs when oxygen difluoride is cooled from – 220 °C to – 230 °C?

[1 mark]

Tick **one** box.

Condensing ☐

Evaporating ☐

Freezing ☐

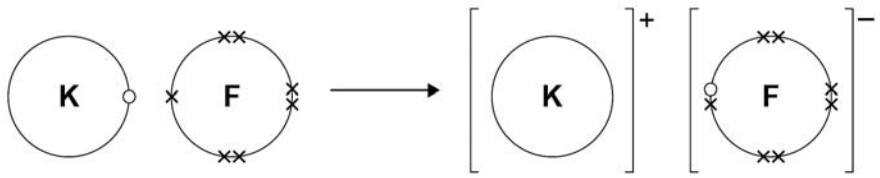
Melting ☐

Question 3 continues on the next page

Potassium reacts with fluorine to produce the ionic compound potassium fluoride (KF).

Figure 7 shows the transfer of electrons during the reaction.

Figure 7



0 3 . 4 Describe what happens when potassium reacts with fluorine to produce potassium fluoride.

Write about electron transfer in your answer.

[5 marks]

0 3 . 5 Potassium fluoride is an ionic compound.

Explain why ionic compounds have high melting points.

Use the following words in your answer:

- attraction
- energy
- ions.

[4 marks]

13

Turn over for the next question

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

0 4 This question is about compounds of oxygen.

The reaction between carbon and oxygen is exothermic.

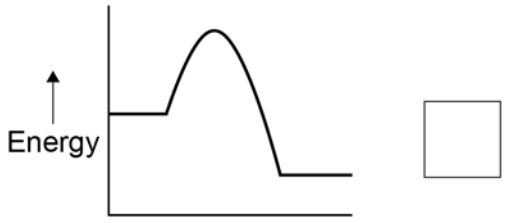
0 4 . 1 What does exothermic reaction mean?

[1 mark]

0 4 . 2 Which is the correct reaction profile (energy level diagram) for an exothermic reaction?

[1 mark]

Tick **one** box.



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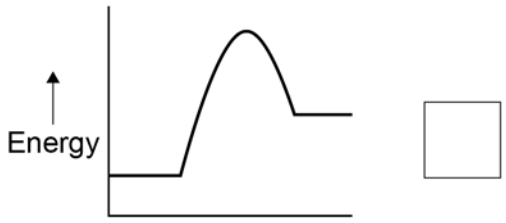

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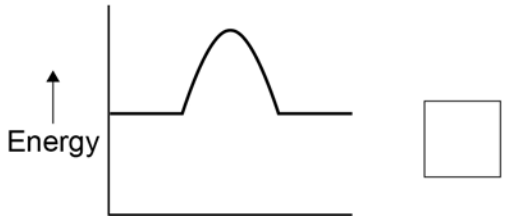


☐

Question 4 continues on the next page

0 4 . 3 The percentage by mass of oxygen in carbon dioxide (CO_2) is calculated by the equation:

$$\text{percentage by mass} = \frac{\text{number of atoms of O} \times \text{Relative atomic mass of oxygen (O)}}{\text{relative molecular mass of carbon dioxide } (CO_2)} \times 100$$

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

Calculate the percentage by mass of oxygen in carbon dioxide (CO_2).

[3 marks]

Percentage by mass of oxygen = _____ %

Hydrogen peroxide decomposes to produce water and oxygen.

0 4 . 4 Balance the chemical equation.

[1 mark]

$$\_\_\_\_\_\ H_2O_2 \rightarrow \_\_\_\_\_\ H_2O + O_2$$

0 4 . 5 6.8 g of hydrogen peroxide decomposes to produce 3.6 g of water.

Calculate the mass of oxygen produced when 68 g of hydrogen peroxide decomposes.

[2 marks]

Mass of oxygen = _____ g

8

Turn over for the next question

0 5 This question is about atoms and chemical elements.

Mendeleev's periodic table has groups of elements with similar properties.

Figure 8 shows part of Mendeleev's periodic table.

Figure 8

1	1 H							
2	7 Li	9.4 Be	11 B	12 C	14 N	16 O	19 F	
3	23 Na	24 Mg	27.3 Al	28 Si	31 P	32 S	35.5 Cl	
4	39 K	40 Ca	44	48 Ti	51 V	52 Cr	55 Mn	56 59 59 63 Fe, Co, Ni, Cu

0 5 . 1 Compare Mendeleev's periodic table with the modern periodic table.

Which group is missing from Mendeleev's periodic table?

[1 mark]

Tick **one** box.

Group 1 ☐

Group 2 ☐

Group 7 ☐

Group 0 ☐

0 5 . 2 In the early periodic tables some elements were placed in the wrong groups.

Mendeleev overcame some of these problems in his periodic table.

Give **two** ways Mendeleev did this.

[2 marks]

1 _____

_____

2 _____

_____

Atoms were thought to be tiny spheres that could not be divided.

0 5 . 3 Draw **one** line from each scientist to the discovery the scientist made.

[2 marks]

Scientist	**Discovery the scientist made**
	Discovered electrons
Neils Bohr	Electrons orbit the nucleus
	Existence of neutrons
James Chadwick	Mass of atom concentrated at centre
	Proton found in nucleus

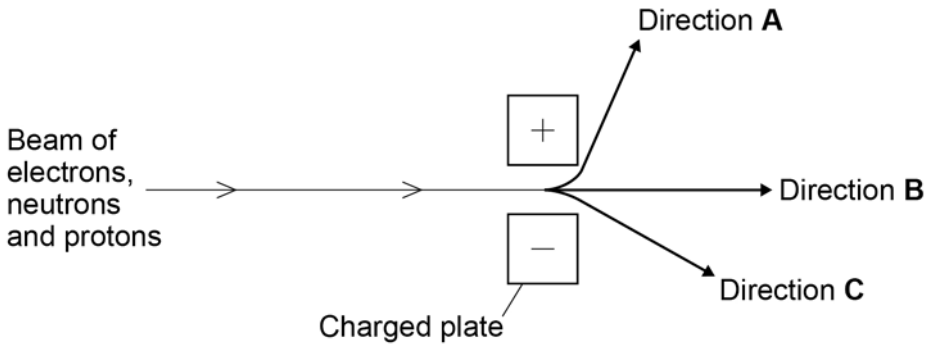
Question 5 continues on the next page

Turn over ►

0 5 . 4 A beam of electrons, neutrons and protons can be separated by passing them through an electric field.

Figure 9 shows the directions of the three particles after entering the electric field.

Figure 9



Charged particles are attracted to the oppositely charged plate in the electric field.

Which direction, **A**, **B** or **C**, does each particle follow?

Complete **Table 1**.

[2 marks]

Table 1

Particle	**Direction**
Electron	
Neutron	
Proton	

0 5 . 5 Calculate the mass of one atom of sodium.

Use the equation:

$$\text{mass of one atom of sodium} = \frac{\text{relative atomic mass}}{\text{Avogadro constant}}$$

Avogadro constant = 6.02×10^{23}

Give your answer to 2 significant figures.

[3 marks]

Mass = _____ g

0 5 . 6 The radius of a sodium atom is 227 picometres.

1 picometre = 10^{-12} metres (m)

The radius of a nucleus is $\frac{1}{10\,000}$ of that of the atom.

Which calculation shows the radius of a sodium atom's nucleus?

[1 mark]

Tick **one** box.

$227 \times 10\,000$ m ☐

$227 \times \frac{1}{10\,000}$ m ☐

$227 \times 10^{-12} \times 10\,000$ m ☐

$227 \times 10^{-12} \times \frac{1}{10\,000}$ m ☐

11

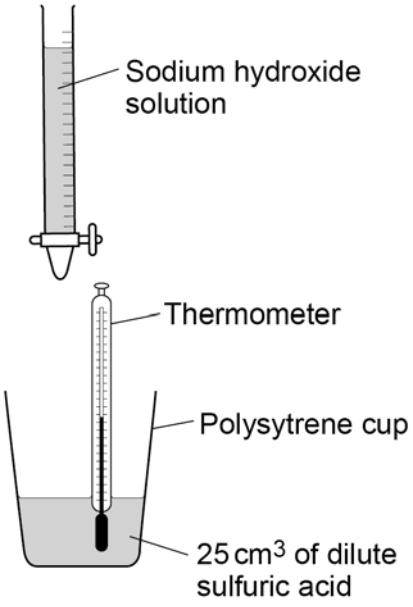
0 6 Some students investigated the change in temperature as sodium hydroxide solution Is added to dilute sulfuric acid.

This is the method used.

1. Put 25 cm^3 of dilute sulfuric acid into a polystyrene cup.
2. Measure the initial temperature of the dilute sulfuric acid.
3. Add 4 cm^3 of sodium hydroxide solution to the dilute sulfuric acid.
4. Stir the mixture.
5. Measure the highest temperature of the mixture.
6. Repeat steps 3–5 until 40 cm^3 of sodium hydroxide solution have been added.

Figure 10 shows the apparatus the student used.

Figure 10



0 6 . 1 The volume of sodium hydroxide solution is a variable.

Which **two** words can be used to describe this type of variable?

[2 marks]

Tick **two** boxes.

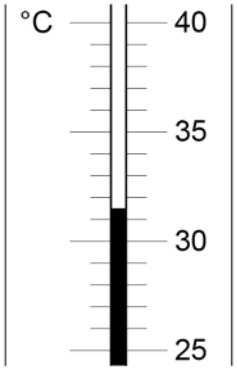
- Categoric ☐
- Continuous ☐
- Control ☐
- Dependent ☐
- Independent ☐

Question 6 continues on the next page

0 6 . 2 The dilute sulfuric acid has an initial temperature of 24.0 °C

Figure 11 shows the highest temperature.

Figure 11



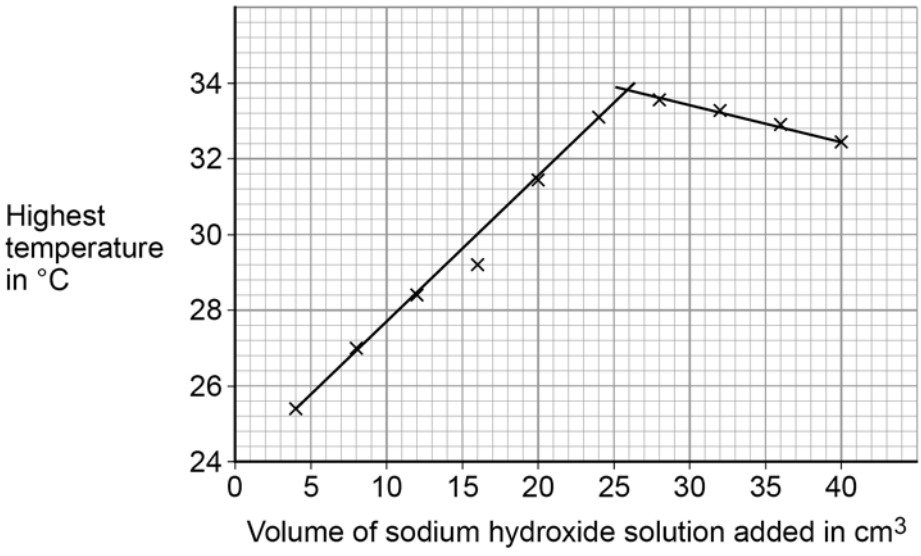
Calculate the change in temperature.

[2 marks]

Temperature = _____ °C

Figure 12 shows the students' results.

Figure 12



0 6 . 3 Determine the volume of sodium hydroxide solution that gives the highest temperature change.

Use **Figure 12** to help you answer this question.

[1 mark]

Volume = _____ cm^3

0 6 . 4 In **Figure 12** the temperature when 16 cm^3 of sodium hydroxide solution is added is anomalous.

Suggest **one** error that could have been made in the method which would cause this anomalous result.

[1 mark]

_____

_____

0 6 . 5 The sodium hydroxide solution in this investigation contains 80 grams per dm^3

The students use 40 cm^3 of sodium hydroxide solution.

Calculate the mass of sodium hydroxide in 40 cm^3

[3 marks]

_____

_____

_____

_____

_____

Mass = _____ g

9

Turn over for the next question

0 7 This question is about metals and metal compounds.

0 7 . 1 Copper oxide reacts with hydrochloric acid to produce copper chloride and water.

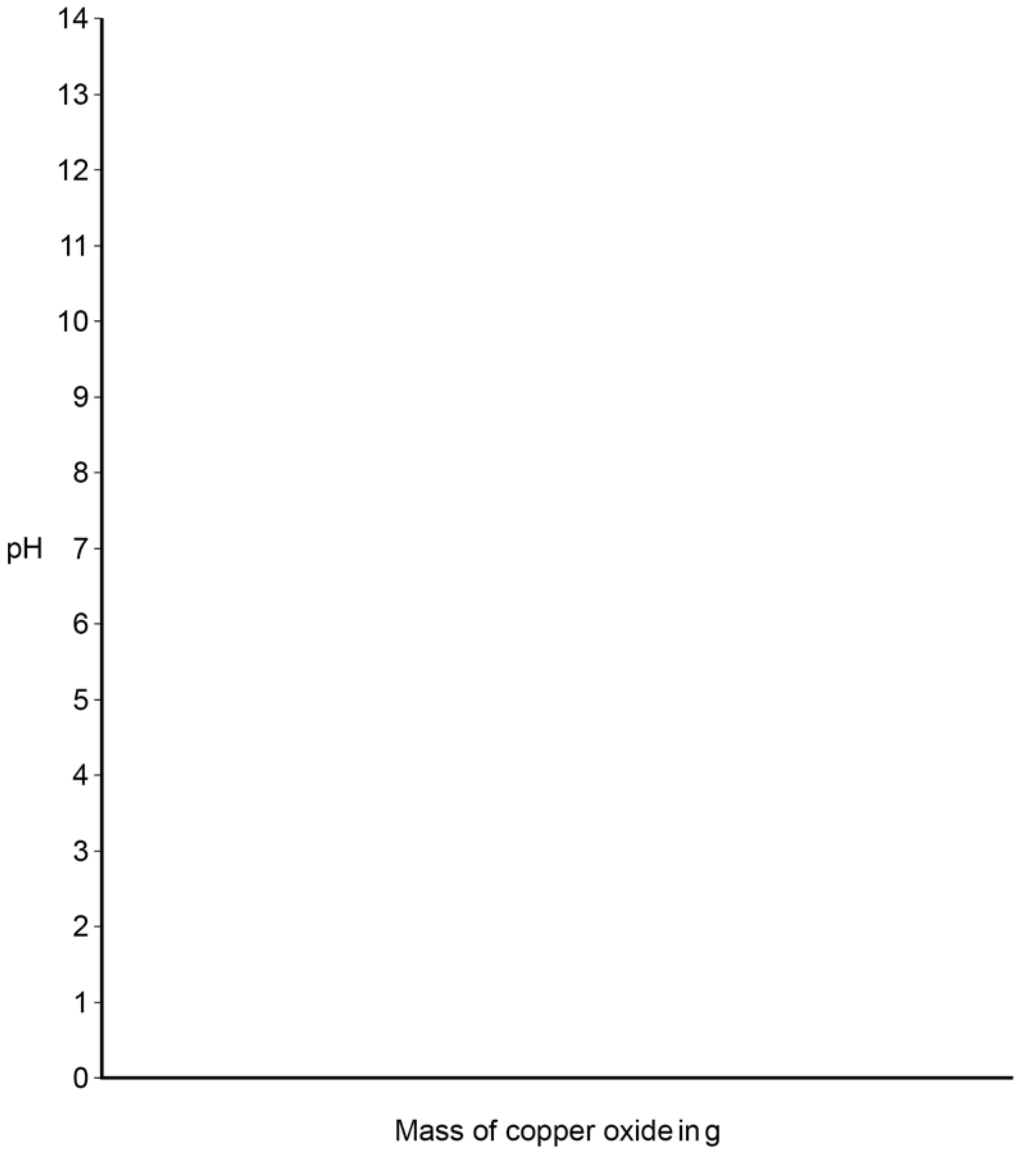
Copper oxide is insoluble in water.

Copper oxide is gradually added to hydrochloric acid until in excess.

Sketch a graph on **Figure 13** to show how the pH of the hydrochloric acid would change.

[3 marks]

Figure 13



0 7 . 2 Magnesium reacts with hydrochloric acid to produce magnesium chloride and hydrogen.

Plan an investigation to find the accurate volume of hydrogen produced from magnesium.

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

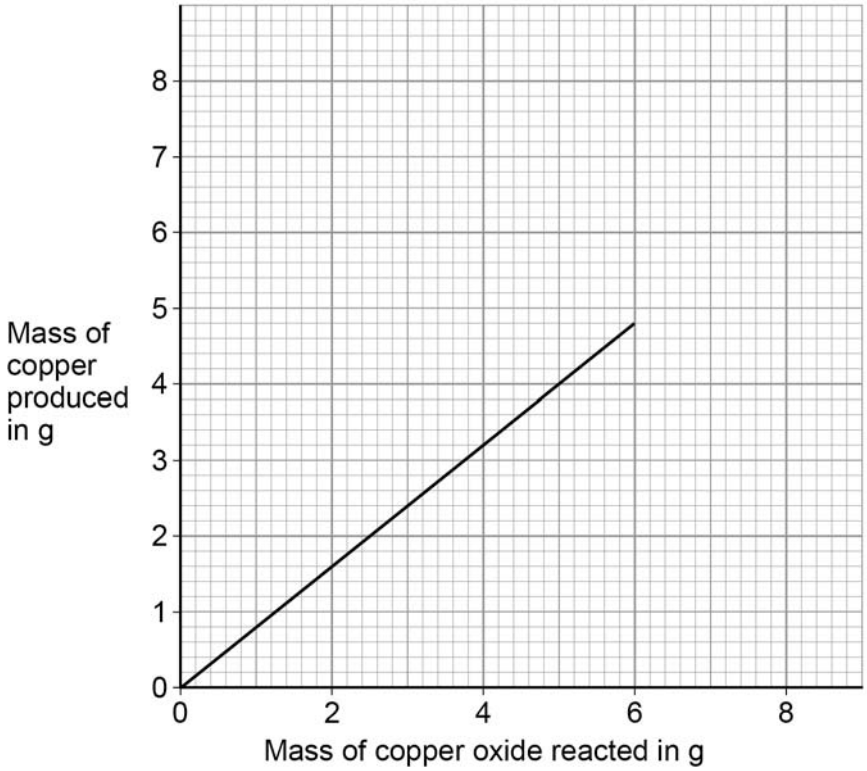
[6 marks]

Question 7 continues on the next page

A student reacts different masses of copper oxide with excess zinc to produce copper.

Figure 14 shows the student's results.

Figure 14



0 7 . 3 Calculate the gradient (slope) of the line on **Figure 14**.

[2 marks]

Gradient = _____ g of copper per g of copper oxide

0 7 . 4 Determine the mass of copper that can be produced from 75 g of copper oxide.

Use **Figure 14**.

[3 marks]

Mass = _____ g

14

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

GCSE
COMBINED SCIENCE: TRILOGY

H

Higher Tier — Chemistry Paper 1H

Specimen 2018 (set 2) — Time allowed: 1 hour 15 minutes

Materials

For this paper you must have:
- a ruler
- a scientific calculator
- the periodidc table (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

Information
- The maximum mark for this paper is 70.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

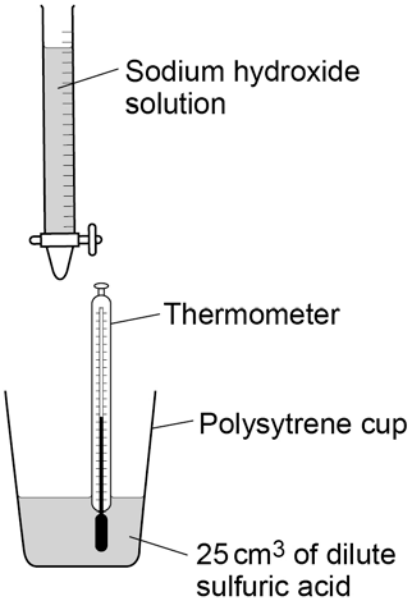
0 1 Some students investigated the change in temperature as sodium hydroxide solution is added to dilute sulfuric acid.

This is the method used.

1. Put 25 cm^3 of dilute sulfuric acid into a polystyrene cup.
2. Measure the initial temperature of the dilute sulfuric acid.
3. Add 4 cm^3 of sodium hydroxide solution to the dilute sulfuric acid.
4. Stir the mixture.
5. Measure the highest temperature of the mixture.
6. Repeat steps 3–5 until 40 cm^3 of sodium hydroxide solution have been added.

Figure 1 shows the apparatus the student used.

Figure 1



0 1 . 1 The volume of sodium hydroxide solution is a variable.

Which **two** words can be used to describe this type of variable?

[2 marks]

Tick **two** boxes.

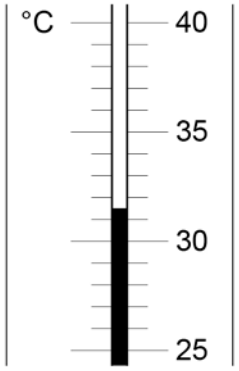
- Categoric ☐
- Continuous ☐
- Control ☐
- Dependent ☐
- Independent ☐

Question 1 continues on the next page

0 1 . 2 The dilute sulfuric acid has an initial temperature of 24.0 °C

Figure 2 shows the highest temperature.

Figure 2



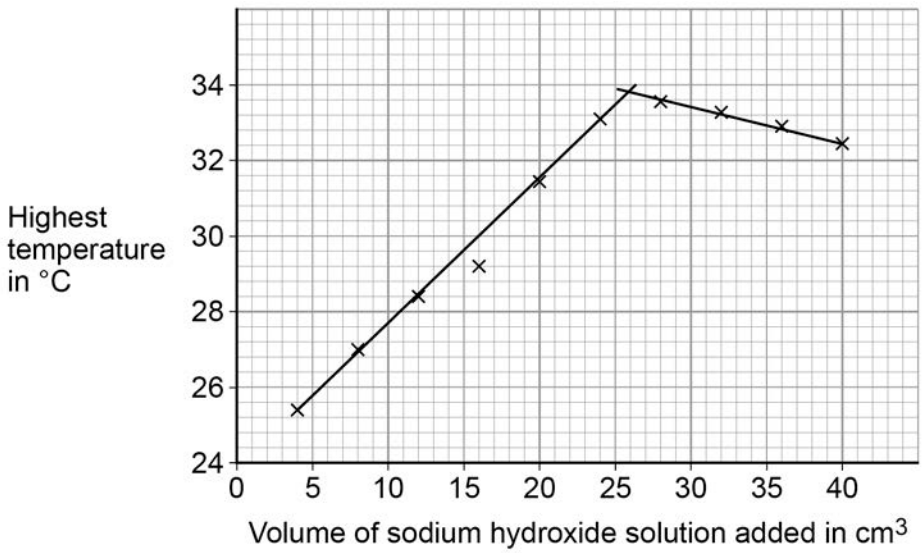
Calculate the change in temperature.

[2 marks]

Temperature = _____ °C

Figure 3 shows the students' results.

Figure 3



0 1 . 3 Determine the volume of sodium hydroxide solution that gives the highest temperature change.

Use **Figure 3** to help you answer this question.

[1 mark]

Volume = _____ cm^3

0 1 . 4 In **Figure 3** the temperature when 16 cm^3 of sodium hydroxide solution is added is anomalous.

Suggest an error that could have been made in the method which would cause this anomalous result.

[1 mark]

_____

_____

0 1 . 5 The sodium hydroxide solution in this investigation contains 80 grams per dm^3

The students use 40 cm^3 of sodium hydroxide solution.

Calculate the mass of sodium hydroxide in 40 cm^3

[3 marks]

_____

_____

_____

_____

_____

Mass = _____ g

9

Turn over for the next question

0 2 This question is about metals and metal compounds.

0 2 . 1 Copper oxide reacts with hydrochloric acid to produce copper chloride and water.

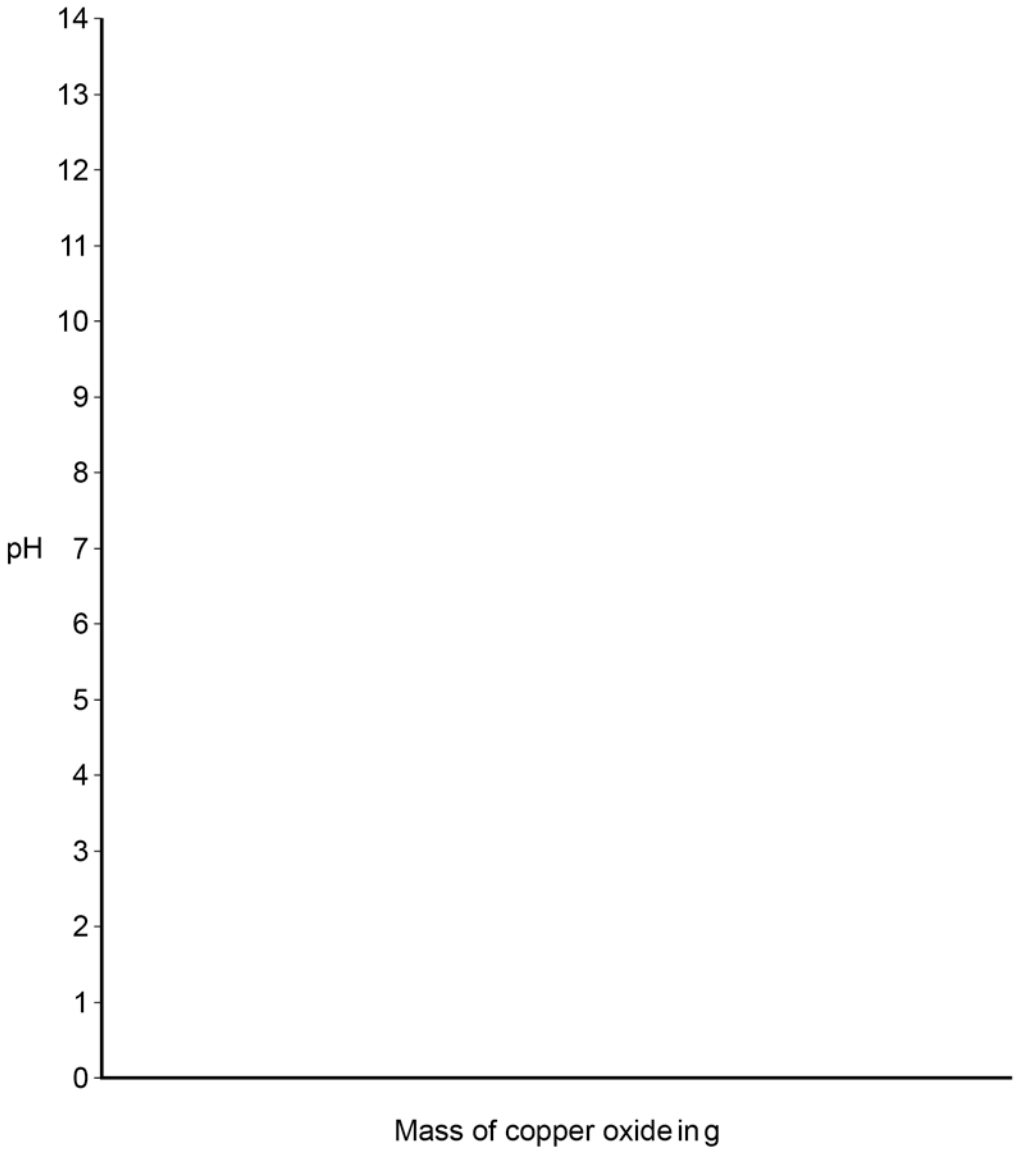
Copper oxide is insoluble in water.

Copper oxide is gradually added to dilute hydrochloric acid until in excess.

Sketch a graph on **Figure 4** to show how the pH of the hydrochloric acid would change.

[3 marks]

Figure 4



0 2 . 2 Magnesium reacts with dilute hydrochloric acid to produce magnesium chloride and hydrogen.

Plan an investigation to find the accurate volume of hydrogen produced from magnesium.

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

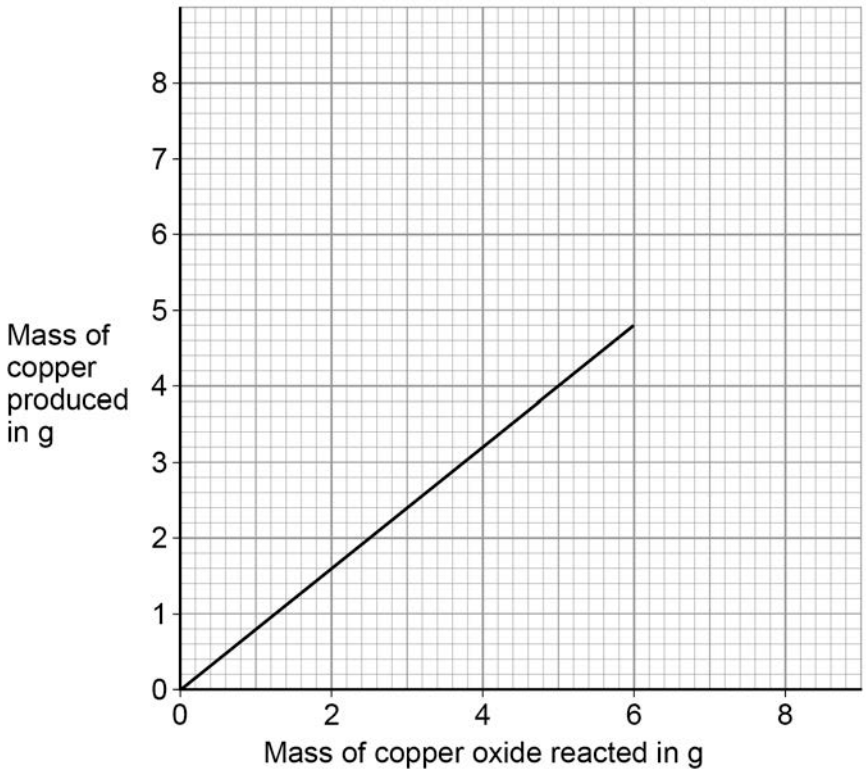
[6 marks]

Question 2 continues on the next page

A student reacts different masses of copper oxide with excess zinc to produce copper.

Figure 5 shows the student's results.

Figure 5



0 2 . 3 Calculate the gradient (slope) of the line on **Figure 5**.

[2 marks]

Gradient = _____ g of copper per g of copper oxide

0 2 . 4 Determine the mass of copper that can be produced from 75 g of copper oxide.

Use **Figure 5**.

[3 marks]

Mass = _____ g

14

Turn over for the next question

0 3 Three substances are all solid at room temperature.

Table 1 describes tests and the result of each test on the three substances.

Table 1

Substance	Effect of large force applied	Effect of heating gently at first, then strongly	Effect of passing electricity through solid	Effect of passing electricity through liquid
A	Breaks into many pieces	Easily melts and then boils	Does not conduct	Does not conduct
B	Breaks into many pieces	No change	Does not conduct	Conducts
C	Becomes thinner	No change	Conducts	Conducts

0 3 . 1 The covalent bonds in the molecules are not overcome when substance **A** is heated.

What forces are overcome when substance **A** melts?

[1 mark]

0 3 . 2 What could substance **A** be?

[1 mark]

Tick **one** box.

Graphite ☐

Iron ☐

Sodium chloride ☐

Sulfur ☐

0 3 . 3 Suggest why substance **B** conducts electricity as a liquid but does **not** conduct electricity as a solid.

[3 marks]

0 3 . 4 Suggest why substance **C** becomes thinner when a large force is applied.

[2 marks]

0 3 . 5 What could substance **C** be?

[1 mark]

Tick **one** box.

- Copper ☐
- Diamond ☐
- Iodine ☐
- Magnesium oxide ☐

8

0 4 This question is about fluorine.

0 4 . 1 Calcium reacts with fluorine to produce calcium fluoride (CaF_2).

Explain how oxidation and reduction have taken place in this reaction.

Write about electron transfer in your answer.

[4 marks]

0 4 . 2 Explain why calcium fluoride has a high melting point.

[4 marks]

0 4 . 3 Fluorine reacts with sulfur to produce sulfur hexafluoride (SF_6).

$$S + 3F_2 \rightarrow SF_6$$

Relative formula masses, M_r: $F_2 = 38$ $SF_6 = 146$

Calculate the mass of sulfur hexafluoride produced when 0.950 g of fluorine is reacted with an excess of sulfur.

Give your answer to 3 significant figures.

[5 marks]

Mass = _____ g

13

Turn over for the next question

0 5 This question is about oxygen.

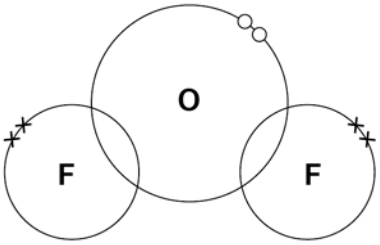
0 5 . 1 One oxygen atom shares one pair of electrons with each fluorine atom in oxygen difluoride (OF_2).

Complete the dot and cross diagram of oxygen difluoride in **Figure 6**.

You should show only the electrons in the outer shells.

[2 marks]

Figure 6



0 5 . 2 Oxygen difluoride (OF_2) has a melting point of – 224 °C and a boiling point of –145 °C

What is the state of oxygen difluoride at room temperature?

Explain your answer in terms of structure and bonding.

[4 marks]

0 5 . 3 The equation shows the reaction of methane with oxygen.

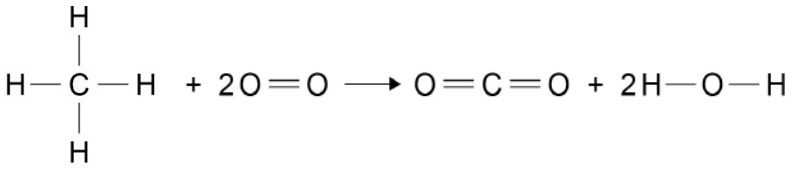


Table 2 shows the bond energies.

Table 2

Bond	**C−H**	**O=O**	**C=O**	**O−H**
Bond dissociation energy in kJ per mole	412	496	803	463

Calculate the overall energy change for the combustion of one mole of methane.

[3 marks]

Energy change = _____ kJ mol^{-1}

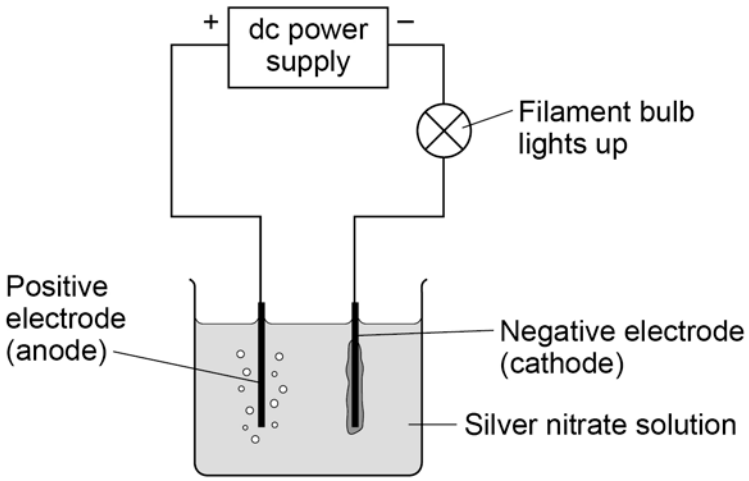
9

Turn over for the next question

0 6 This question is about electrolysis.

0 6 . 1 **Figure 7** shows the apparatus used to electrolyse silver nitrate ($AgNO_3$) solution.

Figure 7



Name the product discharged at each electrode.

Write a half equation for the reaction at each electrode.

[4 marks]

Product at negative electrode (cathode) _____

Half equation for negative electrode

_____

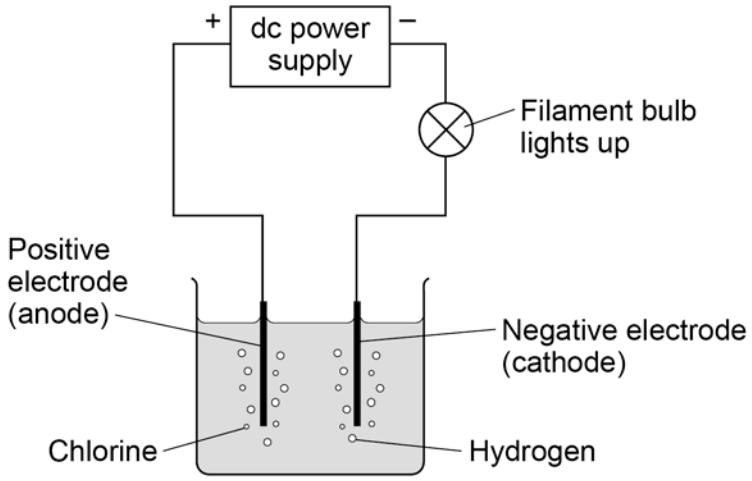
Product at positive electrode (anode) _____

Half equation for positive electrode

_____

0 6 . 2 **Figure 8** shows the apparatus used to electrolyse sodium chloride (NaCl) solution.

Figure 8



Hydrogen and chlorine are produced.

Explain how another different product is formed in solution during this electrolysis.

[4 marks]

8

Turn over for the next question

0 7 This question is about subatomic particles.

0 7 . 1 Subatomic particles in an atom are electrons, protons and neutrons.

Complete **Table 3** to show when each subatomic particle was discovered.

[2 marks]

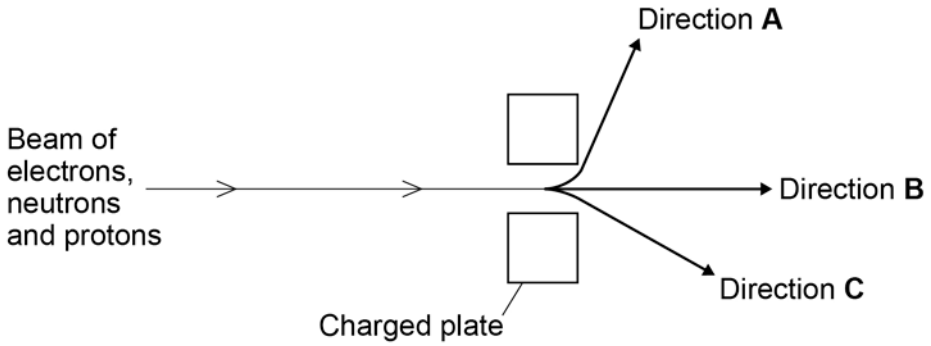
Table 3

Date of discovery	Subatomic particle
1897	
1920	
1932	

0 7 . 2 A beam of electrons, neutrons and protons travelling at the same speed is passed through two oppositely charged plates.

Figure 9 shows the directions of three particles after passing through the charged plates.

Figure 9



The charges on the electric plates are **not** shown.

The heavier the particle the less the deflection.

Explain which directions the electrons, neutrons and protons will take.

[4 marks]

Question 7 continues on the next page

Turn over ►

0 7 . 3 Calculate the mass of one atom of sodium.

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

Give your answer to 3 significant figures.

[2 marks]

Mass of one atom of sodium = _____ g

0 7 . 4 The radius of a sodium atom is 227 picometres (pm)

1 picometre = 1×10^{-12} m

What is the approximate radius of the nucleus of a sodium atom?

Tick **one** box.

[1 mark]

2.27×10^{-12} m ☐

2.27×10^{-14} m ☐

2.27×10^{-24} m ☐

4.54×10^{-14} m ☐

9

END OF QUESTIONS

GCSE

COMBINED SCIENCE: TRILOGY 8464/C/2F

Chemistry Paper 2F

Mark scheme

Specimen (set 2)

Version: 1.0

Keep secure

Please be aware that not all schools and colleges will be using these tests at the same time.

Help us to maintain the security of these papers by ensuring they are not distributed on social media or other platforms.

Important – please note

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers.

It must be stressed that a mark scheme is a working document. This mark scheme has **not** been through the full standardisation process. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way.

Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

The Information to Examiners is included as a guide to how the mark scheme will function as an operational document.

The layout has been kept consistent so that future operational mark schemes do not appear different from these test materials.

Information to Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the Examiner make his or her judgement
- the Assessment Objectives, level of demand and specification content that each question is intended to cover.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

2. Emboldening and underlining

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **or**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

2.4 Any wording that is underlined is essential for the marking point to be awarded.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of error / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (indicated as * in example 1) are not penalised.

Example 1: What is the pH of an acidic solution?

[1 mark]

Student	Response	Marks awarded
1	green, 5	0
2	red*, 5	1
3	red*, 8	0

Example 2: Name two planets in the solar system.

[2 marks]

Student	Response	Marks awarded
1	Neptune, Mars, Moon	1
2	Neptune, Sun, Mars, Moon	0

3.2 Use of chemical symbols / formulae

If a student writes a chemical symbol / formula instead of a required chemical name, full credit can be given if the symbol / formula is correct and if, in the context of the question, such action is appropriate.

3.3 Marking procedure for calculations

Marks should be awarded for each stage of the calculation completed correctly, as students are instructed to show their working. Full marks can, however, be given for a correct numerical answer, without any working shown.

3.4 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.5 Errors carried forward

Any error in the answers to a structured question should be penalised once only.

Papers should be constructed in such a way that the number of times errors can be carried forward is kept to a minimum. Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ecf in the marking scheme.

3.6 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term.

3.7 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.8 Allow

In the mark scheme additional information, 'allow' is used to indicate creditworthy alternative answers.

3.9 Ignore

Ignore is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

3.10 Do <u>not</u> accept

Do **not** accept means that this is a wrong answer which, even if the correct answer is given as well, will still mean that the mark is not awarded.

4. Level of response marking instructions

Extended response questions are marked on level of response mark schemes.

- Level of response mark schemes are broken down into levels, each of which has a descriptor.
- The descriptor for the level shows the average performance for the level.
- There are two marks in each level.

Before you apply the mark scheme to a student's answer, read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1: Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer.

When assigning a level you should look at the overall quality of the answer. Do **not** look to penalise small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2 but be awarded a mark near the top of the level because of the level 3 content.

Step 2: Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this.

The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do **not** have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

You should ignore any irrelevant points made. However, full marks can be awarded only if there are no incorrect statements that contradict a correct response.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Extra information	Mark	AO / Spec. Ref. / Demand
01.1	formulation		1	AO1 5.8.1.2 Low
01.2	1/10		1	AO2 5.8.1.2 Low
01.3	make them palatable		1	AO3 5.8.1.2 Low
01.4	neutralisation		1	AO1 5.4.2.2 Low
01.5	carbon dioxide		1	AO1 5.8.2.3 Low
01.6	water has a boiling point of 100 °C water has a melting point lower than room temperature		1 1	AO1 5.2.2.4 Low
01.7	$CaCl_2$		1	AO1 5.1.1.1 Low
01.8	crushed melted	must be in this order	1 1	AO1 5.10.2.2 Low Standard
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref. / Demand
02.1	0.1%		1	AO2 5.9.1.1 Low
02.2	bar correctly drawn to ± ½ square		1	AO2 5.9.1.1 Low
02.3	argon		1	AO2 5.1.1.1 Low
02.4	increased data values to justify		1 1	AO2 5.9.1.3 Low Standard
02.5	electricity and industry are equal electricity and industry are highest transport is lowest electricity or industry is double transport		1 1 1 1	AO2 AO3 5.9.2.2 Low Standard
02.6	use of renewable energy sources **or** specific example		1	AO1 5.9.2.4 Low
02.7	limited investment in renewable technology **or** disagreement between countries	accept specific reason which relates to response to **02.6**, eg insufficient sunlight	1	AO1 5.9.2.4 Low
Total			**11**	

Question	Answers	Extra information	Mark	AO / Spec. Ref. / Demand
03.1	sodium chloride		1	AO2 5.1.1.1 5.6.1.1 Low
03.2	points correctly plotted correct line of best fit	allow **1** mark if 4 correct do **not** accept straight line	2 1	AO2 5.6.1.1 Low
03.3	0.38–0.50	allow for **1** mark for working shown on graph on **Figure 6**	2	AO2 5.6.1.2 Low
03.4	≥5 seconds and <8 seconds		1	AO2 5.6.1.2 Low
Total			**7**	

Question	Answers	Extra information	Mark	AO / Spec. Ref. / Demand
04.1	2.38	if answer incorrect, allow **1** mark for 2.37 to full calculator display **or** for (4.82 + 2.16 + 0.15) / 3	2	AO2 5.7.1.1 Low
04.2	different types of biomass / plankton	allow they are mixtures	1	AO2 5.7.1.1 Standard
04.3	a molecule		1	AO1 5.2.1.4 Low
04.4	alkanes		1	AO1 5.7.1.1 Low
04.5	**B**		1	AO1 5.7.1.3 Low
04.6	**B**		1	AO1 5.7.1.3 Low
04.7	any **two** from: • cracking uses a catalyst, fractional distillation doesn't • cracking breaks up molecules, fractional distillation separates them • cracking is a chemical process, fractional distillation is a physical process		2	AO1 5.7.1.2 5.7.1.4 Low Standard
04.8	poly(ethene)		1	AO1 5.2.1.4 5.7.1.4 Low

04.9	(**A**=) reuse (**B**=) recycle		1 1	AO1 5.10.2.2 Low

Total			**12**

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Spec. Ref. / Demand</th></tr>
<tr><td>05.1</td><td>potato

effective, but manageable and safe</td><td>

allow 1 for manganese dioxide is effective</td><td>1

1</td><td>AO3.
5.6.1.4
Low</td></tr>
<tr><td>05.2</td><td>75 cm^3</td><td></td><td>1</td><td>AO2
5.6.1.4
Low</td></tr>
<tr><td>05.3</td><td>headings: time, volume

units: s or seconds, cm^3

correct values for times, including 0

correct values for volumes</td><td><table><tr><th>Time in seconds</th><th>Volume in cm^3</th></tr><tr><td>0</td><td>0</td></tr><tr><td>20</td><td>23</td></tr><tr><td>40</td><td>42</td></tr><tr><td>60</td><td>59</td></tr><tr><td>80</td><td>72</td></tr><tr><td>100</td><td>80</td></tr><tr><td>120</td><td>88</td></tr></table></td><td>1

1

1

1</td><td>AO2
5.6.1.4
Low
Standard</td></tr>
<tr><td>05.4</td><td>any one from:
• gas escaped
• leak
• slow to put on bung
• systematic error</td><td></td><td>1</td><td>AO3
5.6.1.4
Low</td></tr>
<tr><td>05.5</td><td>any two from:
• concentration of peroxide
• volume of peroxide
• temperature
• mass of catalyst
• surface area of catalyst</td><td></td><td>2</td><td>AO2
5.6.1.4
Low</td></tr>
<tr><td>Total</td><td></td><td></td><td>10</td><td></td></tr>
</table>

Question	Answers	Extra information	Mark	AO / Spec. Ref. / Demand
06.1	more than 1 dot in a vertical line		1	AO2 5.8.1.3 Standard
06.2	correct equation and substitution 7/39 calculation and answer 0.1795 answer to 2 significant figures 0.18	accept R_f = distance moved by spot C / distance moved by solvent	1 1 1	AO1 AO2 5.8.1.3 Standard
06.3	**Level 3:** The plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.		5–6	AO1 AO3 5.8.1.3 Standard
	Level 2: The 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 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 • put dots of known colours, and a dot of the ink on a pencil line on the chromatography paper. • place the bottom of the paper in water, making sure the start line is above the water • leave for solvent to rise up through paper. • when solvent near top of paper, remove and leave to dry. • compare positions of dots for known colours with those from ink			
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref. / Demand
07.1	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$		1	AO1 5.3.1.1 5.7.1.3 Standard
07.2	toxic acid rain **or** respiratory problems global dimming	accept causes death accept respiratory problems / asthma	1 1 1	AO1 5.9.2.3 Standard
07.3	**Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.		5–6	AO3 5.7.1.2 5.9.2.2 5.9.3.1 5.9.3.2 Standard
	Level 2: Some logically linked reasons are given. There may also be a simple judgement.		3–4	
	Level 1: Relevant points are made. They are not logically linked.		1–2	
	No relevant content		0	
	Indicative content • methane is the best fuel because it gives more energy per gram than coal, and gives less carbon dioxide per kJ of energy produced • petrol is best because it being a liquid it is easier to handle than gas or coal - although the energy content is lower than the others, it gives out less carbon dioxide than coal • methane has more energy per gram than coal • coal produces most carbon dioxide • coal can produce sulfur dioxide			
Total			**10**	