

Name: _____

Energy Changes part 4 AQA Triple Chemistry

Class: _____

Date: _____

Time: **75 minutes**

Marks: **72 marks**

Comments:

1.

Some students investigated the energy changes occurring in the reaction between potassium hydrogencarbonate and hydrochloric acid.

The equation for the reaction is:



This is the method used.

1. Measure 50 cm³ hydrochloric acid into a glass beaker.
2. Measure the temperature of the hydrochloric acid.
3. Measure a given mass of potassium hydrogencarbonate.
4. Add the potassium hydrogencarbonate to the hydrochloric acid.
5. Stir until all the potassium hydrogencarbonate has reacted.
6. Record the lowest temperature reached.
7. Repeat three more times, using the same mass of potassium hydrogencarbonate.

Each student used a different mass of potassium hydrogencarbonate.

- (a) The method described will not give very accurate results.

Suggest **one** change to the apparatus that would improve the accuracy of the results.

Give a reason for your answer.

(2)

- (b) The students controlled the volume of the hydrochloric acid.

Give **one** other control variable the students should use.

(1)

(c) The table shows one student's results.

	Trial 1	Trial 2	Trial 3	Trial 4
Initial temperature in °C	21.2	21.1	21.0	21.1
Final temperature in °C	15.6	15.4	15.6	16.6
Temperature decrease in °C	5.6	5.7	5.4	4.5

Calculate the mean temperature decrease for the results shown in the table above.

Ignore any anomalous results.

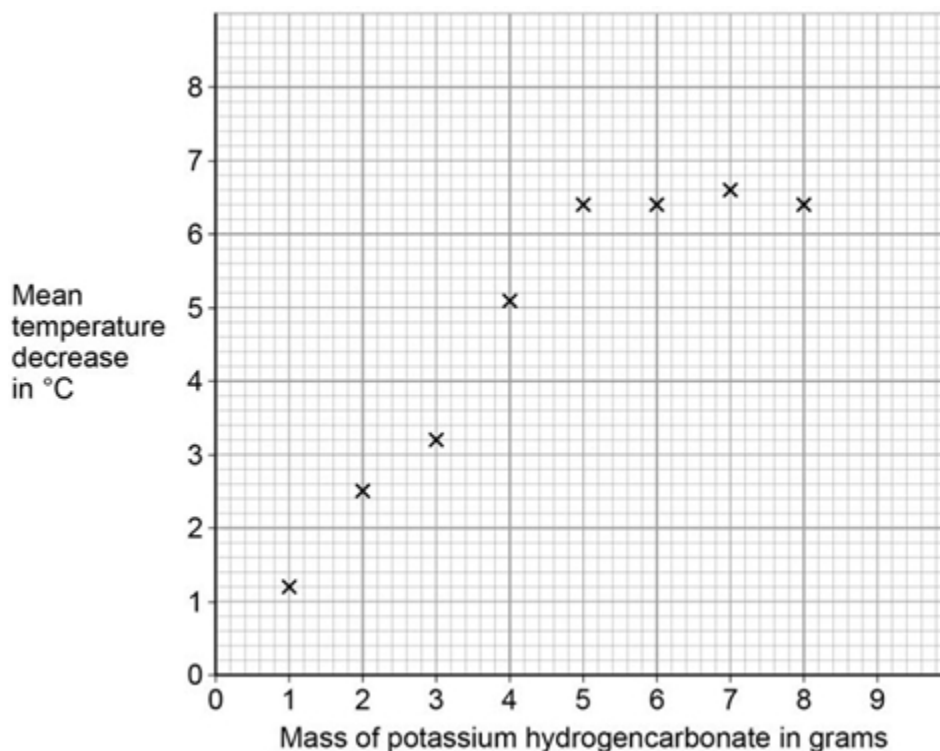
Give your answer to 1 decimal place.

Give the uncertainty in your answer.

Mean = _____ °C ± _____ °C

(3)

The graph below shows the students' results.



(d) Draw **two** intersecting straight lines of best fit on the graph above.

(2)

(e) Explain why the graph has this shape.

Use data from the graph.

(3)

(f) Suggest a possible reason for the anomalous points.

Do **not** include errors in measuring.

(1)

(Total 12 marks)

2.

This question is about energy changes in chemical reactions.

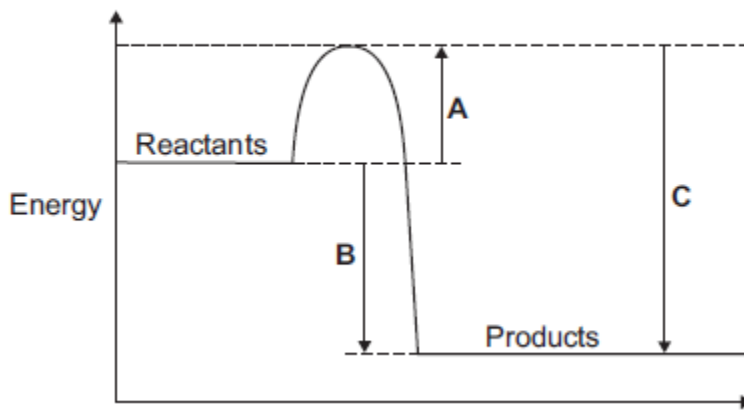
(a) Complete the word equation for the combustion of hydrogen.



(1)

(b) **Figure 1** shows a simple energy level diagram.

Figure 1



(i) Which arrow, **A**, **B** or **C**, shows the activation energy?

Tick (✓) **one** box.

A

B

C

(1)

(ii) What type of reaction is shown by the energy level diagram in **Figure 1**?
Give a reason for your answer.

Type of reaction _____

Reason _____

(2)

(iii) For a reaction, the value of **A** is 1370 kJ and **C** is 3230 kJ.
Calculate the value of **B**.

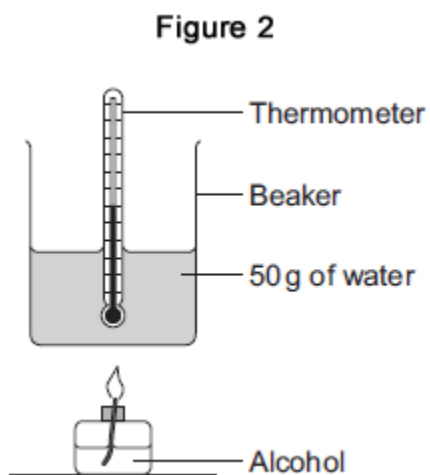
B = _____ kJ

(1)

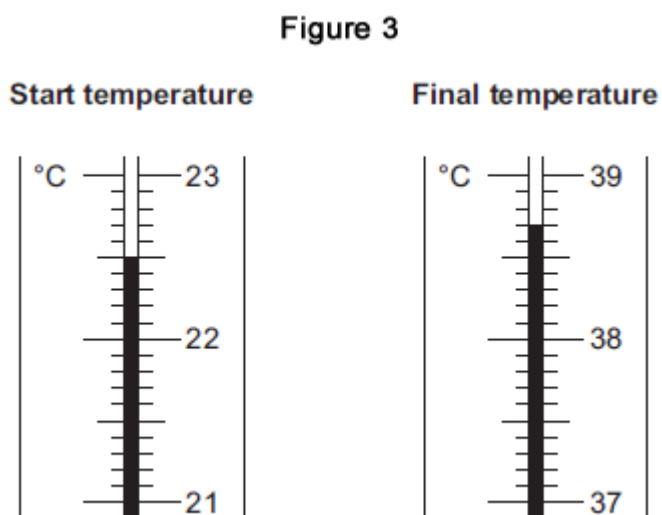
(c) Alcohols are used as fuels.

A group of students investigated the amount of energy released when different alcohols are burned.

The students used the apparatus shown in **Figure 2**.



(i) **Figure 3** shows the start temperature and the final temperature of the water.



Write the start temperature and the final temperature of the water in **Table 1**.
Work out the increase in temperature to complete **Table 1**.

Table 1

Start temperature of the water in °C	
Final temperature of the water in °C	
Increase in temperature in °C	

(3)

- (ii) The students worked out the heat energy released by burning 1 g of each alcohol. The students used the equation:

$$\text{Heat energy released} = m \times 4.2 \times \text{increase in temperature}$$

Look at **Figure 2**. What is the value of m ?

$$m = \text{_____ g}$$

(1)

- (iii) **Table 2** shows the students' results.

Table 2

Name of alcohol	Number of carbon atoms in one molecule of alcohol	Heat energy released when 1 g of alcohol is burned in kJ
Methanol	1	11.4
Ethanol	2	13.5
Propanol	3	20.1
Butanol	4	16.8
Pentanol	5	17.2

Which value of heat energy released is anomalous?

(1)

- (iv) Look at **Table 2**.
What is the relationship between the number of carbon atoms in one molecule of alcohol and the heat energy released when 1 g of the alcohol is burned?

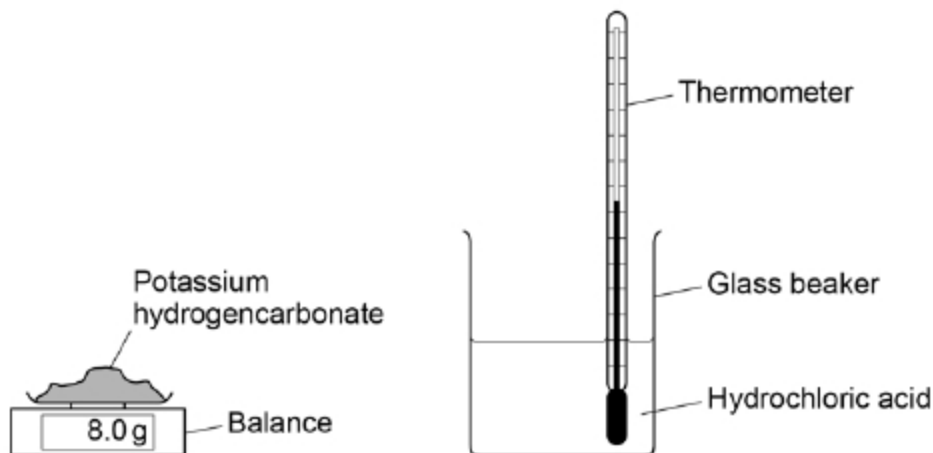
(1)

3.

A student investigated the energy change occurring in the endothermic reaction between potassium hydrogencarbonate and hydrochloric acid.

Figure 1 shows the apparatus used.

Figure 1



This is the method used.

1. Measure 50 cm³ hydrochloric acid into a glass beaker.
2. Measure 1.0 g of potassium hydrogencarbonate.
3. Add the potassium hydrogencarbonate to the hydrochloric acid.
4. Stir until all the potassium hydrogencarbonate has reacted.
5. Record the lowest temperature reached.
6. Repeat steps 1–5 two more times.
7. Repeat steps 1–6 with different masses of potassium hydrogencarbonate.

(a) Which is the most suitable apparatus to use to measure 50 cm³ of hydrochloric acid?

Tick (✓) **one** box.

Balance

Conical flask

Gas syringe

Measuring cylinder

(1)

(b) The student used a glass beaker for the reaction.

Suggest **one** change to the apparatus that would improve the accuracy of the results.

Give a reason for your answer.

(2)

(c) Which **two** variables should the student keep the same to make this a fair test?

Tick **two** boxes.

- | | |
|---|--------------------------|
| Mass of potassium hydrogencarbonate | <input type="checkbox"/> |
| Same balance | <input type="checkbox"/> |
| Same thermometer | <input type="checkbox"/> |
| Starting temperature of hydrochloric acid | <input type="checkbox"/> |
| Volume of hydrochloric acid | <input type="checkbox"/> |

(2)

(d) **Figure 2** shows part of the thermometer used to measure the temperature.



What is the temperature reading on the thermometer?

Temperature = _____ °C

(1)

The table shows a set of results.

	Test 1	Test 2	Test 3
Lowest temperature in °C	16.1	15.8	15.9

(e) What is the range of the lowest temperature?

From _____ °C to _____ °C

(1)

(f) Calculate the mean lowest temperature.

Use the table above.

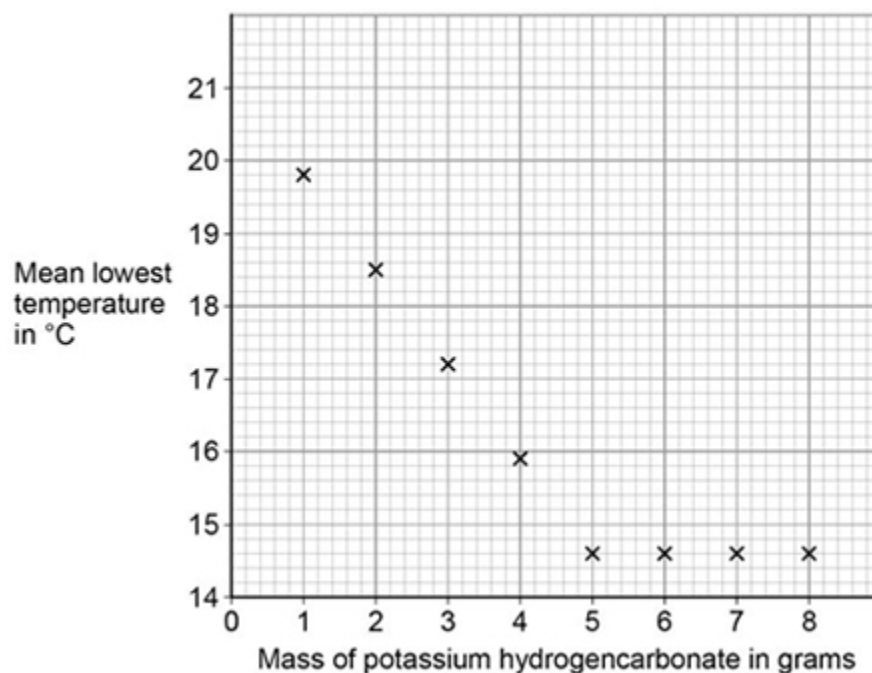
Mean lowest temperature = _____ °C

(2)

(g) How do the results show that the reaction is endothermic?

(1)

The graph shows the student's results.



(h) Draw **two** straight lines of best fit on the graph above.

(2)

(i) Describe how the lowest temperature changes as the mass of potassium hydrogencarbonate added increases.

(3)

(Total 15 marks)

4.

Cells contain chemicals which react to produce electricity.

(a) Why can a rechargeable cell be recharged?

(1)

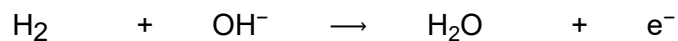
(b) Give **two** factors that affect the voltage produced by a cell.

1. _____

2. _____

(2)

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



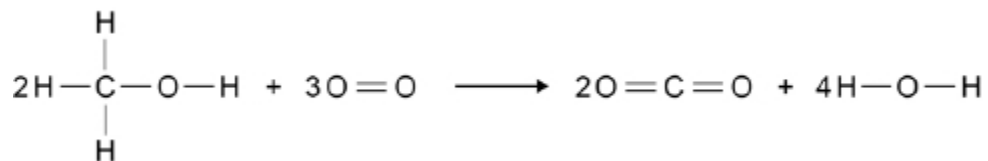
(1)

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

(1)

(e) Another type of fuel cell uses methanol instead of hydrogen.

The diagram represents the reaction in this fuel cell.



The table shows the bond energies for the reaction.

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

Calculate the overall energy change for the reaction.

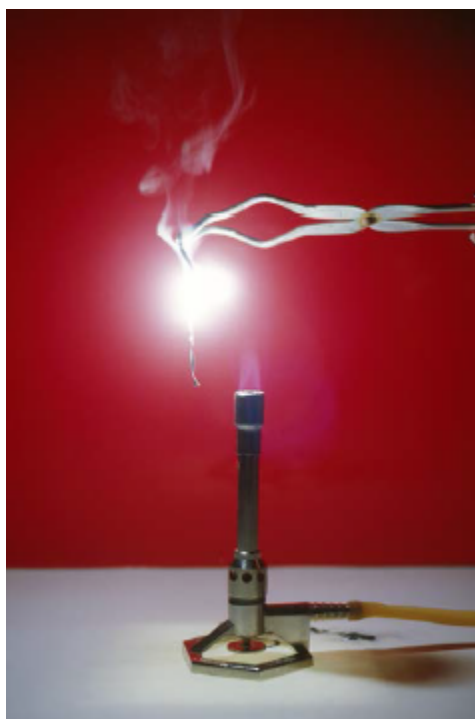
Use the diagram and the table above.

Overall energy change = _____ kJ / mol

(3)
(Total 8 marks)

5.

The figure below shows magnesium burning in air.



© Charles D Winters/Science Photo Library

(a) Look at the figure above.

How can you tell that a chemical reaction is taking place?

(1)

(b) Name the product from the reaction of magnesium in the figure.

(1)

(c) The magnesium needed heating before it would react.

What conclusion can you draw from this?

Tick **one** box.

The reaction is reversible

The reaction has a high activation energy

The reaction is exothermic

Magnesium has a high melting point

(1)

(d) A sample of the product from the reaction in the figure above was added to water and shaken.

Universal indicator was added.

The universal indicator turned blue.

What is the pH value of the solution?

Tick **one** box.

1

4

7

9

(1)

(e) Why are nanoparticles effective in very small quantities?

Tick **one** box.

They are elements

They are highly reactive

They have a low melting point

They have a high surface area to volume ratio

(1)

(f) Give **one** advantage of using nanoparticles in sun creams.

(1)

(g) Give **one** disadvantage of using nanoparticles in sun creams.

(1)

(h) A coarse particle has a diameter of 1×10^{-6} m.
A nanoparticle has a diameter of 1.6×10^{-9} m.

Calculate how many times bigger the diameter of the coarse particle is than the diameter of the nanoparticle.

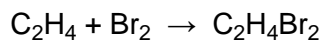
(2)

(Total 9 marks)

6.

This question is about the reaction of ethene and bromine.

The equation for the reaction is:

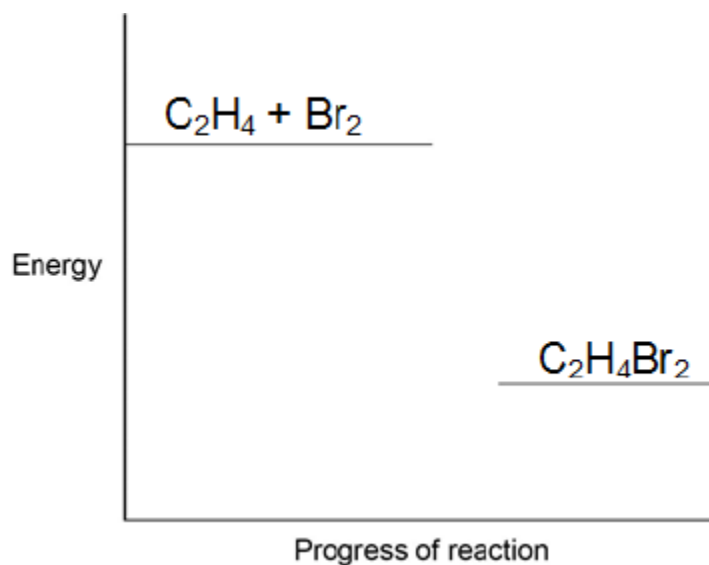


(a) Complete the reaction profile in **Figure 1**.

Draw labelled arrows to show:

- The energy given out (ΔH)
- The activation energy.

Figure 1



(3)

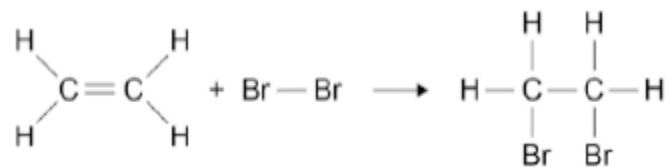
(b) When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

Explain how a covalent bond holds two atoms together.

(2)

(c) **Figure 2** shows the displayed formulae for the reaction of ethene with bromine.

Figure 2



The bond enthalpies and the overall energy change are shown in the table below.

	C=C	C-H	C-C	C-Br	Overall energy change
Energy in kJ / mole	612	412	348	276	-95

Use the information in the table above and **Figure 2** to calculate the bond energy for the Br-Br bond.

Bond energy _____ kJ / mole

(3)

Mark schemes

1.

- (a) use a polystyrene cup instead of a (glass) beaker
allow insulate the beaker
allow use a lid 1
- minimises energy transfer from the surroundings
or
for better insulation 1
- (b) concentration of hydrochloric acid 1
- (c) $\frac{5.6 + 5.7 + 5.4}{3}$ 1
- = 5.6 (°C) 1
- ± 0.2 1
- (d) straight line from origin to (5.0, 6.4)
must not deviate to anomalous point 1
- horizontal line from (5.0, 6.4) to (8.0, 6.4)
must not deviate to anomalous point 1
- (e) as mass (of potassium hydrogencarbonate) increases, temperature decrease / change increases 1
- until 5 g (to 8 g) (of potassium hydrogencarbonate has been added)*
allow ecf from lines of best fit 1
- (because) the reaction has finished
or
(because) all the acid has reacted
or
(because) no more solid can react
or
(because) the solid is in excess 1
- (f) not stirred correctly 1

[12]

2.	(a) water / H ₂ O <i>allow steam or hydrogen oxide</i>	1
	(b) (i) A	1
	(ii) exothermic products (energy) lower than reactants (energy)	1
	(iii) 1860 (kJ)	1
	(c) (i) 22.5 38.7 16.2 <i>allow ecf for correct subtraction</i>	1
	(ii) 50 (g)	1
	(iii) 20.1 (kJ) <i>allow propanol</i> <i>ignore 3</i>	1
	(iv) as the number of carbon atoms (in one molecule of alcohol) increases the heat energy given out increases (when the alcohol is burned)	1
	(v) any two from: <ul style="list-style-type: none"> • no lid • no insulation • no draught shield <i>Allow heat / energy loss to surroundings for any one of these marks</i> <ul style="list-style-type: none"> • incomplete combustion • inaccurate measurement • no repeats (to calculate a mean) 	2
	(iv) -O-H	1
		[14]
3.	(a) measuring cylinder	1

- (b) use a polystyrene cup
allow insulate the beaker and / or use a lid 1
- better insulator
- or**
- reduces energy transfer from the surroundings 1
- (c) starting temperature of hydrochloric acid 1
- volume of hydrochloric acid 1
- (d) 21.4 (°C) 1
- (e) 15.8 (°C) to 16.1 (°C)
allow 16.1 (°C) to 15.8 (°C) 1
- (f)
$$\frac{16.1 + 15.8 + 15.9}{3}$$
 =15.9 (°C)
an answer of 15.9(333..) (°C) scores 2 marks 1
allow 15.9(333..) (°C) 1
- (g) temperature decreases 1

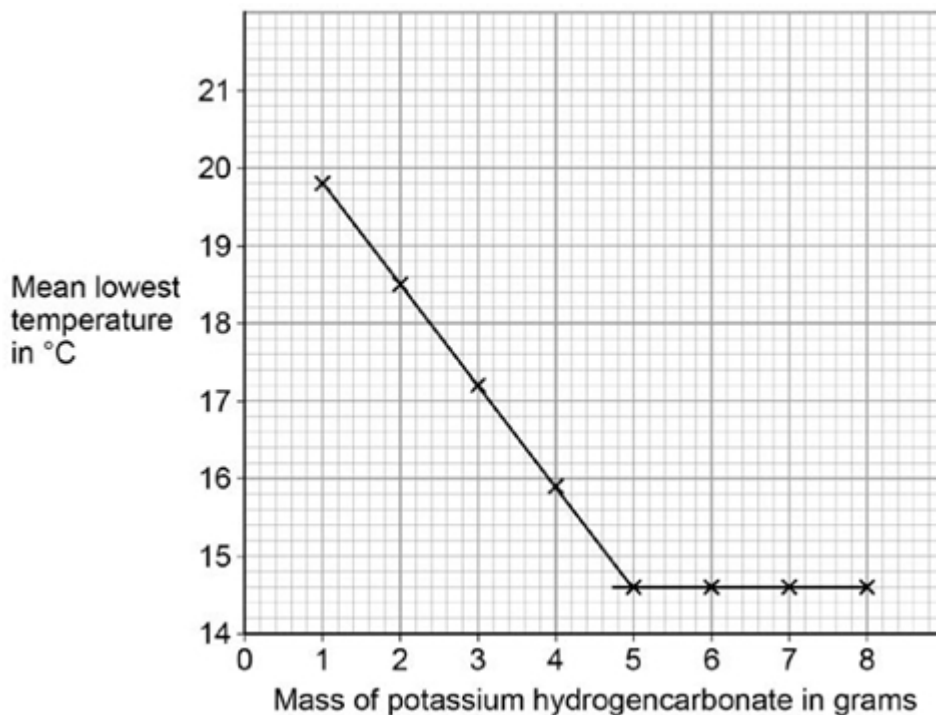
(h) straight line from (1.0, 19.8) to (5.0, 14.6)
ignore continuation of line in either direction

1

horizontal straight line from (5.0, 14.6 to 8.0, 14.6)
ignore continuation of line in either direction

1

the answer below scores **2** marks



(i) (lowest) temperature decreases

1

to 14.6 °C
or
until 5 g added

1

then no change to temperature (after 5 g solid added)
or
then temperature remains at 14.6 °C (after 5 g solid added)

1

[15]

4.

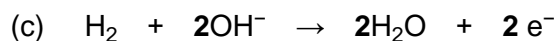
(a) the chemical reaction is reversible

1

(b) any **two** from:

- type of electrode
- electrolyte
- concentration of electrolyte
- temperature

2



allow multiples

1

(d) contains OH^- ions

1

(e) (bonds broken)

$$((6 \times 412) + (2 \times 360) + (2 \times 464) + (3 \times 498)) = 5614$$

1

(bonds made)

$$((4 \times 805) + (8 \times 464)) = 6932$$

1

(overall energy change)

$$(6932 - 5614) = -1318 \text{ (kJ / mol)}$$

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

1

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

[8]

5.

(a) any **one** from:

- there was a flame
- energy was given out
- a new substance was formed
- the magnesium turned into a (white) powder

answers must be from the figure

1

(b) Magnesium oxide

1

(c) The reaction has a high activation energy

1

(d) 9

1

(e) They have a high surface area to volume ratio

1

(f) any **one** from:

- Better coverage
- More protection from the Sun's ultraviolet rays

1

(g) any **one** from:

- Potential cell damage to the body
- Harmful effects on the environment

1

(h) indication of $\frac{1}{1.6} = 0.625$

and

use of indices $10^{-9} - 10^{-6} = 10^3$

Both steps must be seen to score first mark

1

$0.625 \times 1000 = 625$ (times bigger)

1

[9]

6.

(a) line goes up before it goes down

1

energy given out correctly labelled

1

activation energy labelled correctly

1

(b) electrostatic force of attraction between shared pair of negatively charged electrons

1

and both positively charged nuclei

1

(c) bonds formed = $348 + 4(412) + 2(276) = 2548$ kJ / mol

1

bonds broken – bonds formed = $612 + 4(412) + (\text{Br-Br}) - 2548 = 95$ kJ / mol

1

Alternative approach without using C-H bonds

For step 1 allow = $348 + 2(276) = 900$ kJ / mol

Then for step 2 allow $612 + (\text{Br-Br}) - 900 = 95$ kJ / mol

193 (kJ / mol)

1

accept (+)193 (kJ / mol) with no working shown for **3** marks

-193(kJ / mol) scores **2** marks

allow ecf from step 1 and step 2

(d) **Level 3 (5–6 marks):**

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. A conclusion is reached.

Level 2 (3–4 marks):

An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

Level 1 (1–2 marks):

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.

0 marks:

No relevant content.

Indicative content

Size and strength

- chlorine atoms have fewer electron energy levels/shells
- chlorine atoms form stronger bonds
- Cl–Cl bond stronger than Br–Br
- C–Cl bond stronger than C–Br

Energies required

- more energy required to break bonds with chlorine
- more energy given out when making bonds with chlorine
- overall energy change depends on sizes of energy changes

Conclusions

- if C–Cl bond changes less, then less exothermic
- if C–Cl bond changes more, then more exothermic
- can't tell how overall energy change will differ as do not know which changes more.

6

[14]