Name: _____

Class: _____

Date: _____

Energy Changes part 2 AQA Triple Chemistry

Time: **78 minutes**

Marks: **74 marks**

Comments:

1. Sodium carbonate reacts with hydrochloric acid in an exothermic reaction.

The equation for the reaction is:

$$Na_2CO_3(s) + 2\ HCl(aq) \rightarrow 2\ NaCl(aq) + CO_2(g) + H_2O(l)$$

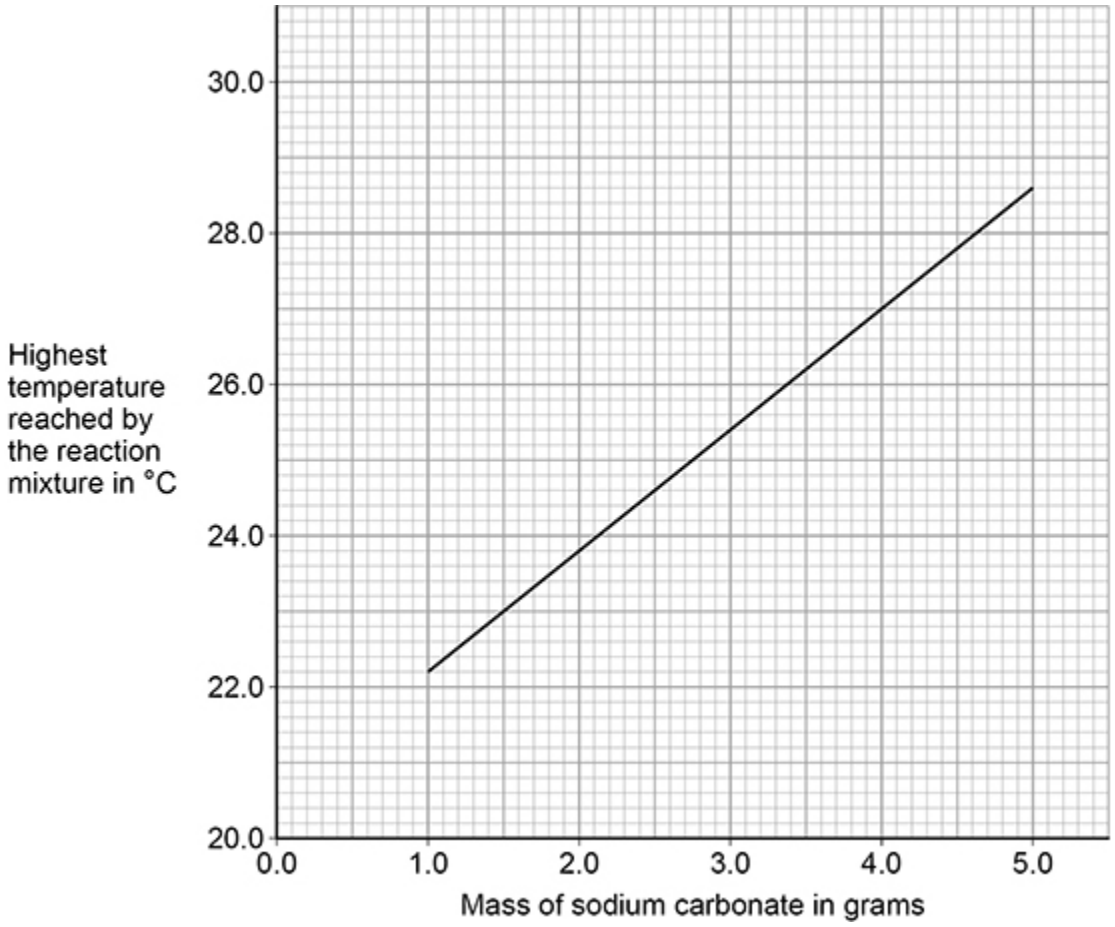
A student investigated the effect of changing the mass of sodium carbonate powder on the highest temperature reached by the reaction mixture.

(a) Plan a method to investigate the effect of changing the mass of sodium carbonate powder on the highest temperature reached.

(6)

Figure 1 shows a line of best fit drawn through the student's results.

Figure 1



(b) Determine the gradient of the line of best fit in **Figure 1**.

Use the equation:

$$\text{Gradient} = \frac{\text{Change in highest temperature}}{\text{Change in mass}}$$

Give the unit.

Gradient = _____ Unit _____

(5)

(c) The initial temperature of the reaction mixture is where the line of best fit would meet the *y*-axis.

Determine the initial temperature of the reaction mixture.

Show your working on **Figure 1**.

Initial temperature of the reaction mixture = _____ °C

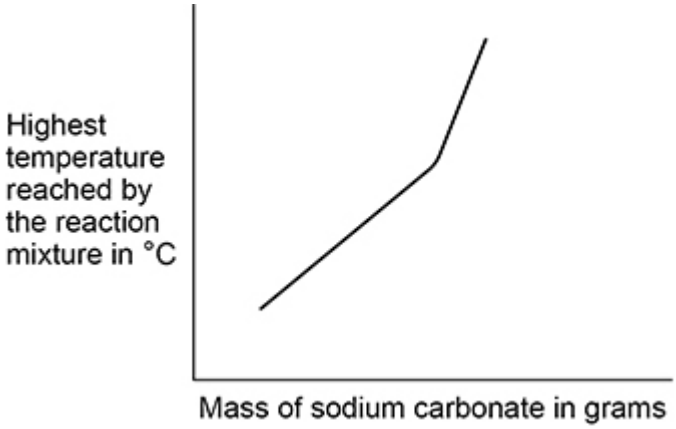
(2)

(d) Another student repeated the investigation but added sodium carbonate until the sodium carbonate was in excess.

Which sketch graph shows the results obtained when sodium carbonate was added until in excess?

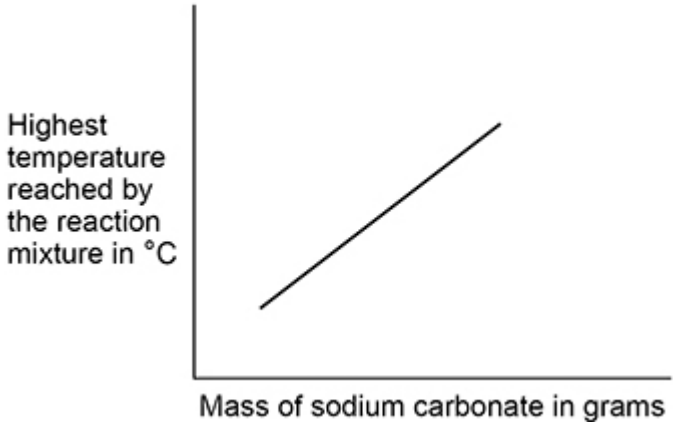
Tick (✓) **one** box.

A



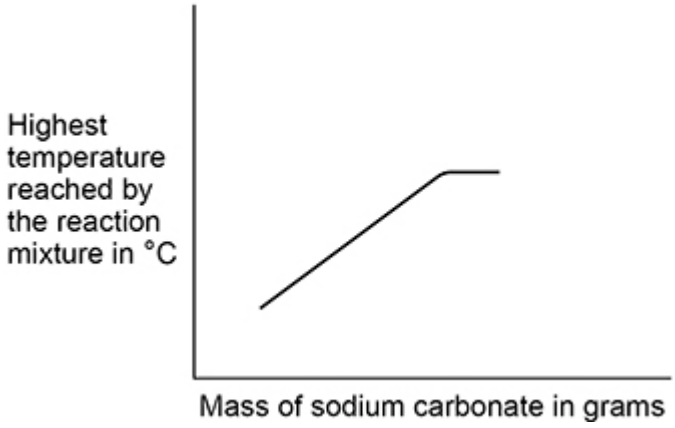
☐

B



☐

C

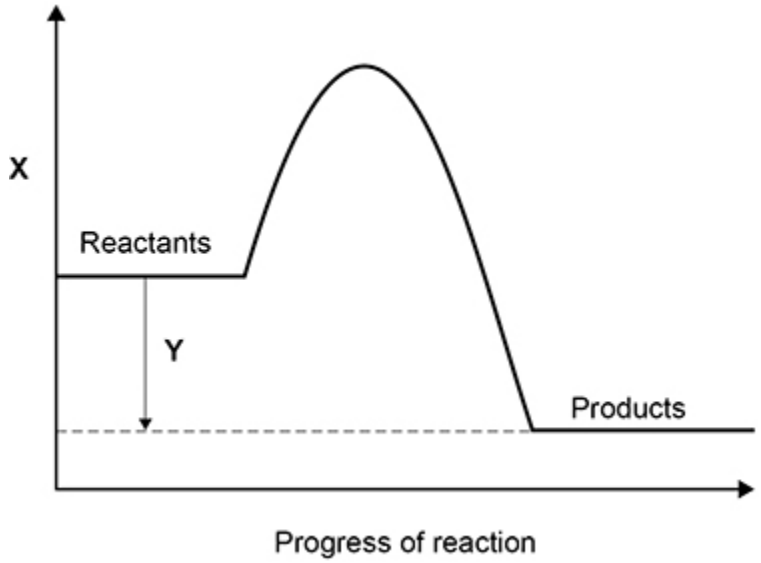


☐

(1)

Figure 2 shows a reaction profile for the reaction of sodium carbonate with hydrochloric acid.

Figure 2



(e) What do labels **X** and **Y** represent on **Figure 2**?

X _____

Y _____

(2)

(f) How does the reaction profile show that the reaction is exothermic?

Use **Figure 2**.

_____

_____

(1)

(Total 17 marks)

2. This question is about zinc and compounds of zinc.

A student produces pure crystals of zinc chloride by reacting zinc oxide with hydrochloric acid.

The equation for the reaction is:

$$ZnO(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$$

(a) The student adds zinc oxide to hydrochloric acid until the zinc oxide is in excess.

Give **one** observation that the student could make to show that the zinc oxide is in excess.

_____

_____

(1)

(b) Why is excess zinc oxide used rather than excess hydrochloric acid?

_____

_____

(1)

(c) Name **one other** compound that the student could add to hydrochloric acid to produce zinc chloride.

_____

_____

(1)

(d) Describe how the student should obtain crystals of zinc chloride from a solution of zinc chloride.

_____

_____

_____

_____

(2)

Zinc chloride is also produced in a displacement reaction between zinc and copper chloride solution.

The equation for the reaction is:

$$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$$

(e) Complete the ionic equation for this reaction.

$$Zn + \_\_\_\_\_ \rightarrow Zn^{2+} + \_\_\_\_\_$$

(1)

(f) Why is zinc described as being oxidised in this reaction?

_____

_____

(1)

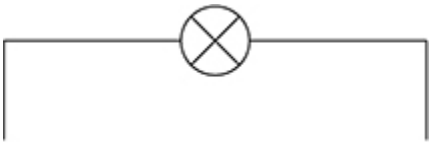
(g) Zinc and copper can be used with another substance to produce electricity.

Complete the figure below to show how zinc, copper and another substance can be used to light a lamp.

Label:

- zinc
- copper
- the other substance used.

The symbol  represents the lamp.



(3)

(Total 10 marks)

3. A student investigated the reactivity of metals with hydrochloric acid.

This is the method used.

1. Measure 50 cm^3 of hydrochloric acid into a polystyrene cup.
2. Measure the temperature of the hydrochloric acid.
3. Add one spatula of metal powder to the hydrochloric acid and stir.
4. Measure the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1 to 5 three more times.
7. Repeat steps 1 to 6 with different metals.

The table below shows the student's results.

Metal	**Temperature increase in °C**				**Mean temperature increase in °C**
	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	
Cobalt	6	7	5	9	7
Magnesium	54	50	37	55	**X**
Zinc	18	16	18	20	18

(a) Calculate the mean temperature increase **X** for magnesium in the table above.

Do **not** include the anomalous result in your calculation.

_____

_____

_____

_____

X = _____ °C

(2)

(b) Determine the order of reactivity for the metals cobalt, magnesium and zinc.

Use the table above.

Most reactive _____

_____

Least reactive _____

(1)

(c) The range of measurements either side of the mean shows the uncertainty in the mean temperature increase.

Complete the sentence.

Use the table above.

The mean temperature increase for zinc is 18 ± _____ °C

(1)

(d) What type of variable is the volume of hydrochloric acid in this investigation?

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

(1)

(e) Suggest **one** way of improving **step 3** in the method to give results which are more repeatable.

_____

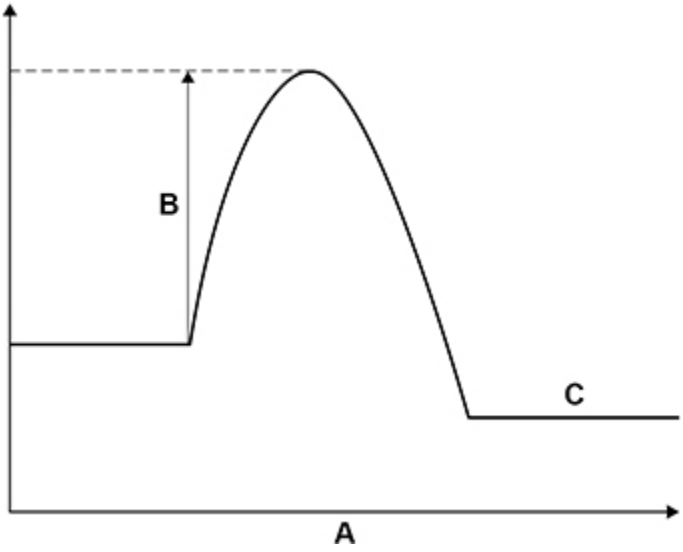
_____

_____

_____

(1)

(f) The figure below shows a reaction profile for the reaction of magnesium with hydrochloric acid.



What do labels **A**, **B** and **C** represent on the figure above?

Choose answers from the box.

activation energy	**energy**	**overall energy change**
products	**progress of reaction**	**reactants**

A _____

B _____

C _____

(3)

(Total 9 marks)

4. This question is about metals.

(a) The table below shows information about four substances.

Substance	Melting point in °C	Boiling point in °C	Does it conduct electricity in the solid state?	Does it conduct electricity in the liquid state?
A	–117	79	No	No
B	801	1413	No	Yes
C	1535	2750	Yes	Yes
D	1610	2230	No	No

Which substance could be a metal?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(b) Explain why alloys are harder than pure metals.

_____

_____

_____

_____

_____

_____

(3)

(c) A student wants to compare the reactivity of an unknown metal, **Q**, with that of zinc.

Both metals are more reactive than silver.

The student is provided with:

- silver nitrate solution
- metal **Q** powder
- zinc powder
- a thermometer
- normal laboratory equipment.

No other chemicals are available.

Describe a method the student could use to compare the reactivity of metal **Q** with that of zinc.

Your method should give valid results.

(4)

(Total 8 marks)

5. This question is about the reaction between hydrogen sulfide (H_2S) and oxygen.

The equation for the reaction is:

$$2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ SO_2(g)$$

(a) What does $H_2O(g)$ represent?

(1)

(b) Calculate the volume of oxygen required to react with 50 cm^3 of hydrogen sulfide.

_____

_____

Volume = _____ cm^3

(1)

(c) **Figure 1** shows part of the reaction profile for the reaction.

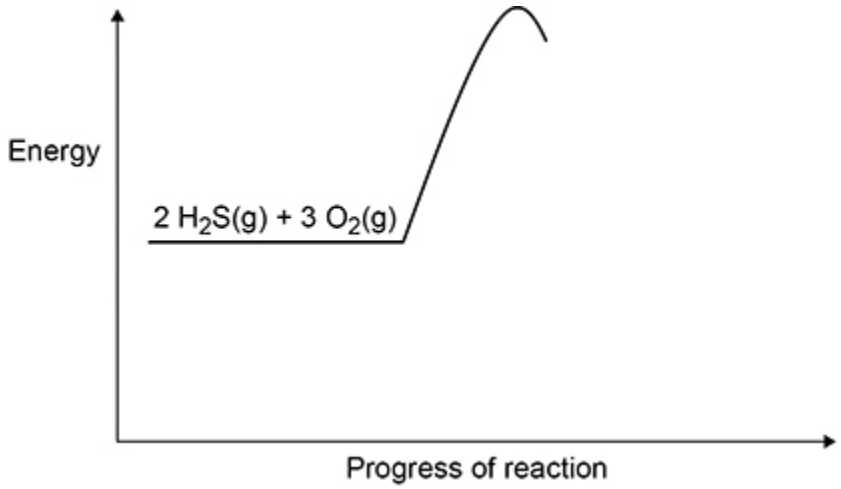
The reaction is exothermic.

Complete **Figure 1**.

You should:

- complete the profile line
- label the activation energy
- label the overall energy change.

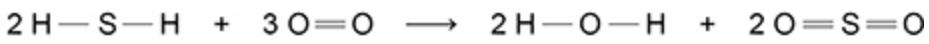
Figure 1



(3)

(d) **Figure 2** shows the displayed formula equation for the reaction of hydrogen sulfide with oxygen.

Figure 2



The table below shows some of the bond energies.

Bond	H — S	O = O	H — O	S = O
Energy in kJ/mol	364	498	464	**X**

In the reaction the energy released forming new bonds is 1034 kJ/mol greater than the energy needed to break existing bonds.

Calculate the bond energy **X** for the bond.

Use **Figure 2** and the table above.

X = _____kJ/mol

(5)

(Total 10 marks)

6. This question is about chemical reactions and energy.

Hydrogen reacts with oxygen to produce water.

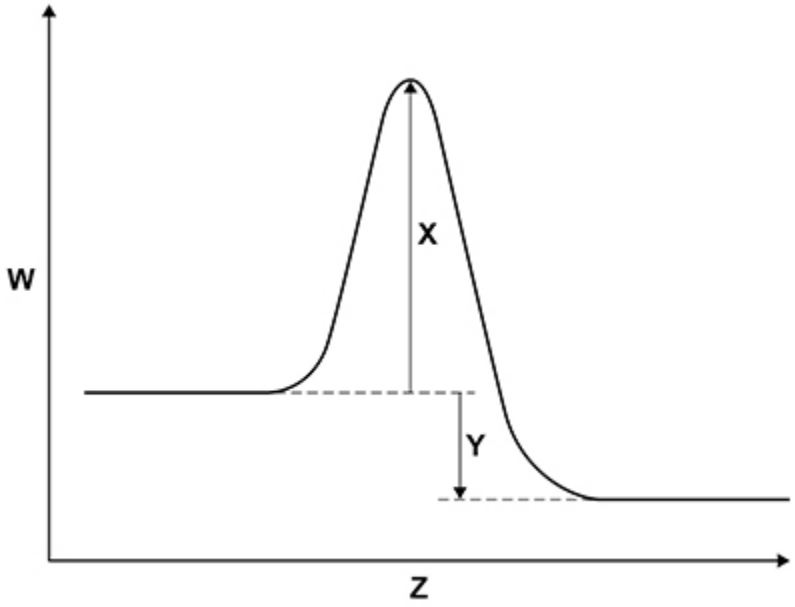
This reaction releases energy.

(a) Complete the word equation for the reaction.

hydrogen + oxygen → _____

(1)

(b) The graph below shows a reaction profile for the reaction between hydrogen and oxygen.



What do the labels **W**, **X**, **Y** and **Z** represent?

Choose answers from the box.

activation energy	**energy**	**overall energy change**
products	**progress of reaction**	**reactants**

W _____

X _____

Y _____

Z _____

(4)

(c) The reaction between hydrogen and oxygen is used in a hydrogen fuel cell.

What is the reason for using this reaction in a fuel cell?

Tick (✓) **one** box.

To produce a change of state ☐

To produce a potential difference ☐

To produce a temperature change ☐

(1)

(d) A student investigated the voltage produced by a chemical cell.

The student used different metals as the electrodes in the cell.

The metals used were:

- copper
- iron
- magnesium.

Which **two** metal electrodes would produce the greatest voltage when used in the chemical cell?

Give **one** reason for your answer.

Metals _____ and _____

Reason _____

_____

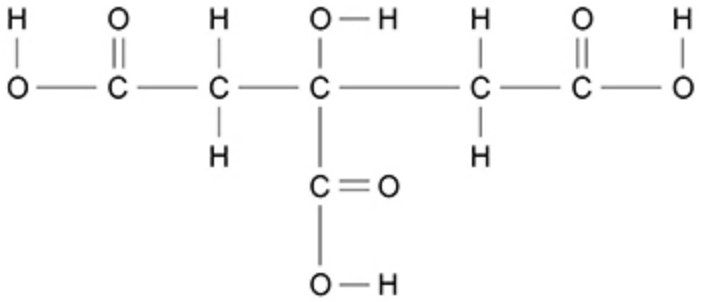
(2)

(Total 8 marks)

7. This question is about citric acid.

Figure 1 represents one molecule of citric acid.

Figure 1



(a) Complete the molecular formula of citric acid.

Use **Figure 1**.

C_6H __ O __

(1)

(b) What type of bonding is shown in **Figure 1**?

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

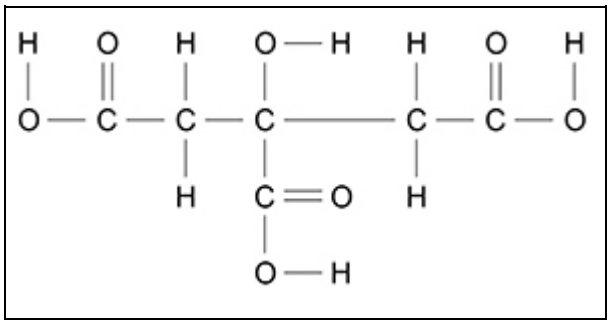
Metallic ☐

(1)

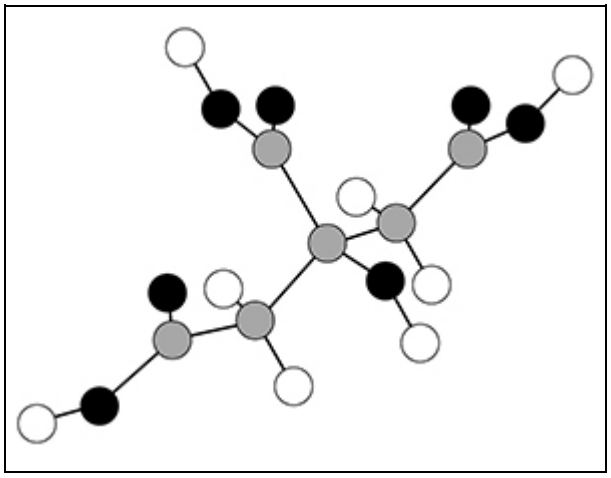
(c) **Figure 2** shows two representations of one molecule of citric acid, **A** and **B**.

Figure 2

A



B



Give **two** advantages of representation **A** compared with representation **B**.

Advantages of **A**:

1 _____

_____

2 _____

_____

(2)

A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

Citric acid is a solid.

This is the method used.

1. Pour 25 cm^3 of sodium hydrogencarbonate solution into a polystyrene cup.
2. Measure the temperature of the sodium hydrogencarbonate solution.
3. Add 0.25 g of citric acid to the cup.
4. Stir the solution.
5. Measure the temperature of the solution.
6. Repeat steps 3 to 5 until a total of 2.00 g of citric acid has been added.

The table below shows some of the student's results.

Mass of citric acid added in g	**Temperature of solution in °C**
0.00	22.6
0.25	22.2
0.50	21.8
0.75	21.4
1.00	21.0
1.25	20.6

(d) How do the results in table above show that the reaction is endothermic?

_____

_____

(1)

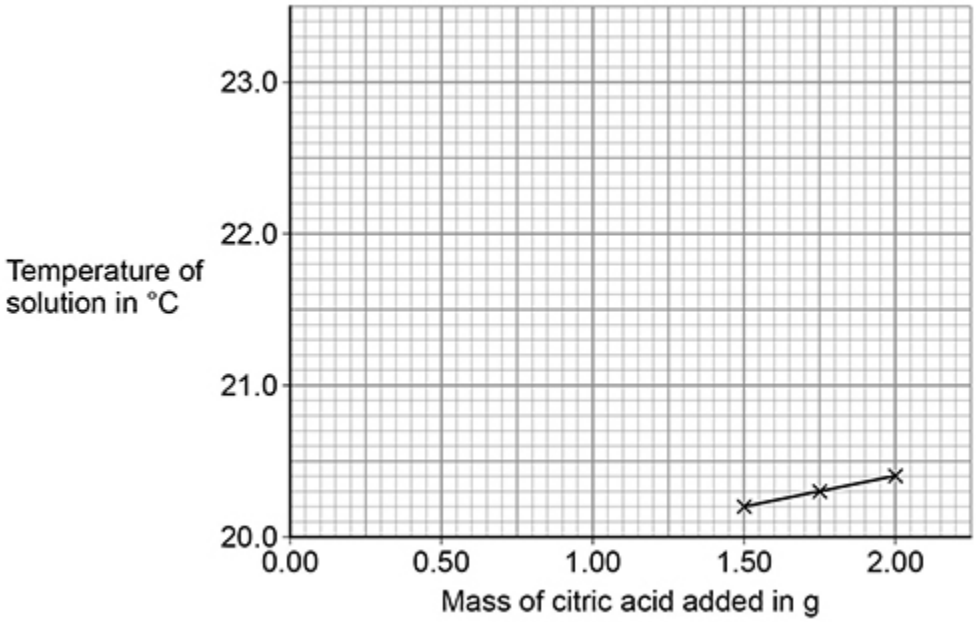
(e) Three of the student's results are plotted on the graph below.

A line of best fit for these points is drawn.

Complete the graph below.

You should:

- plot the data from table above on the graph below
- draw a line of best fit through the points you have plotted
- extend your line of best fit to meet the line of best fit already drawn on the graph below.



(4)

(f) Determine the overall temperature change for the reaction.

Use the graph above.

_____

_____

Overall temperature change = _____ °C

(2)

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

Tick (✓) **one** box.

Mass of citric acid ☐

Temperature of solution ☐

Volume of solution ☐

(1)

(Total 12 marks)

1. (a) **Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content

- **measure volume of (hydrochloric) acid**
- with a measuring cylinder

- pour (hydrochloric) **acid into a suitable container** eg polystyrene cup
- measure the initial temperature (of hydrochloric acid)
- with a thermometer

- **add a known mass of sodium carbonate**
- measured with a balance
- stir

- **measure the highest temperature reached**

- **repeat with different masses of sodium carbonate**
  or
  add successive masses of sodium carbonate to the same mixture

- repeat the whole investigation

- use the same starting temperature
- use the same volume of (hydrochloric) acid each time
- use the same concentration of (hydrochloric) acid each time

(b) **View with Figure 1**

change in highest temperature

allow a tolerance of ± ½ a small square

1

corresponding change in mass

allow a tolerance of ± ½ a small square

1

(gradient =) $\frac{\text{change in highest temperature}}{\text{change in mass}}$

allow correct use of an incorrectly determined change in highest temperature and / or change in mass

1

(gradient =) 1.6

1

°C/g

allow °C/gram(s)

1

(c) **View with Figure 1**

extrapolates line to the *y*-axis

1

20.6 (°C)

allow a tolerance of ± ½ a small square

allow a correctly determined value from an incorrectly extrapolated line

1

alternative approach:

(highest temperature at 1.0 g − change in highest temperature per gram =) 22.2 − 1.6 (1)

*allow correct use of value determined for gradient in part **(b)***

= 20.6 (°C) (1)

(d) **C**

1

(e) (**X**) energy

1

(**Y**) (overall) energy change

1

(f) (level of) products is below (level of) reactants

allow the energy decreases (overall)

allow energy is transferred to the surroundings

ignore references to bond making / breaking

1

[17]

2. (a) (zinc oxide) solid remaining

allow (zinc oxide) solid no longer disappears

ignore references to colour / effervescence

1

(b) (excess) zinc oxide can be filtered off

allow converse statement for hydrochloric acid

allow separation / removal of (excess) zinc oxide is easier

ignore to ensure all the (hydrochloric) acid is used up

1

(c) any **one** from:

- zinc hydroxide

  allow $Zn(OH_2)$

- zinc carbonate

  allow $ZnCO_3$

1

(d) heat (the solution) until crystallisation point is reached

allow heat (the solution) until crystals start to form

allow heat (the solution) to reduce the volume

allow heat (the solution) to evaporate (some of the water)

1

leave the solution (to cool / crystallise)

1

*if no other mark is awarded allow **1** mark for heat the solution to dryness*

(e) $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

ignore state symbols

1

(f) zinc (atoms) lose (2) electrons

*do **not** accept references to oxygen*

1

(g) (a diagram showing)

solution in a container

ignore labels

1

zinc electrode
and
copper electrode
both inserted into solution

ignore polarities on electrodes

1

complete circuit that would function as an electrochemical cell including a labelled electrolyte

allow a named electrolyte in solution

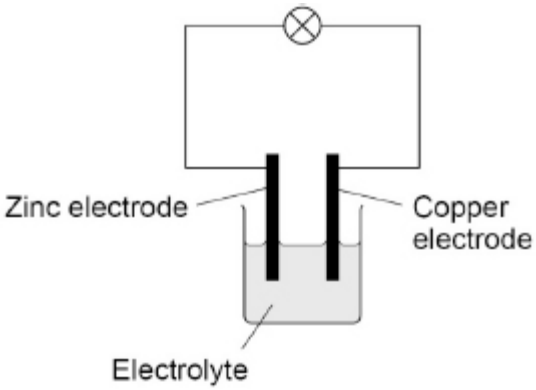
allow a named molten electrolyte

*do **not** accept cell / battery in external circuit*

*do **not** accept a wire between the electrodes*

1

an answer of



scores **3** marks

ignore voltmeter / ammeter regardless of location

[10]

3. (a) $\frac{54 + 50 + 55}{3}$

1

= 53 (°C)

*if no other mark awarded allow **1** mark for*
$\frac{54 + 50 + 37 + 55}{4}$ *= 49 (°C)*

1

(b) (most reactive) magnesium zinc
(least reactive) cobalt

*allow ecf from question **(a)***

1

(c) (18 ±) 2 (°C)

1

(d) control

1

(e) use the same mass of metal / powder

1

(f) (A) progress of reaction

1

(B) activation energy

1

(C) products

1

[9]

4. (a) C

1

(b) (in an alloy) the atoms are of different sizes

1

(so) the layers (of atoms in an alloy) are distorted

1

(so in an alloy) the layers slide over each other less easily (than in a pure metal)

1

(c) measure temperature change

*allow measure the temperature before **and** after the reaction*

1

when each metal is added to silver nitrate solution

1

same concentration / volume of solution
or
same mass / moles of metal

allow same initial temperature (of silver nitrate solution)

1

the greater the temperature change the more reactive

1

[8]

5. (a) water vapour

allow steam

allow gaseous water

1

(b) 75 (cm^3)

1

(c) product level below reactants

ignore labelling of products

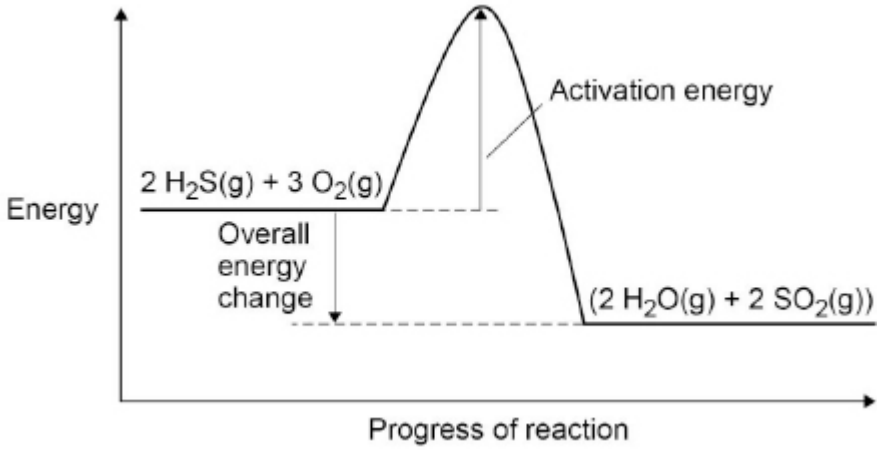
1

activation energy drawn and labelled

1

overall energy change drawn and labelled

if endothermic profile drawn allow corresponding overall energy change



scores **3** marks

1

(d) (bonds broken = 4(364) + 3(498) =) 2950

1

(bonds formed = 2950 + 1034 =) 3984

allow correct use of incorrectly calculated values of bonds broken

1

4**X** + 4(464) = 3984

allow correct use of incorrectly calculated values of bonds formed

1

4**X** = **(**3984 – 1856 =) 2128

1

X = 532 (kJ/mol)

1

alternative approach:

(bonds broken = 4(364) + 3(498) =) 2950 (1)

(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)

(1856 + 4**X**) – 2950 = 1034 (1)

allow correct use of incorrectly calculated values of bonds broken and/or bonds formed

4**X** = (1034 + 2950 – 1856 =) 2128 (1)

X = 532 (kJ/mol) (1)

[10]

6. (a) water

allow H_2O

*do **not** accept energy*

1

(b) W = energy

1

X = activation energy

1

Y = overall energy change

1

Z = progress of reaction

1

(c) to produce a potential difference

1

(d) magnesium **and** copper

1

(the metals) have the largest difference in reactivity

1

[8]

7. (a) $C_6H_8O_7$

1

(b) covalent

1

(c) shows (single and) double bonds

1

shows which atoms are which element

1

(d) temperature decreases (during the reaction)

allow (the solution) gets colder

1

(e) all six points plotted correctly

allow a tolerance of ± ½ small square
*allow **1** mark for four / five points plotted correctly*

2

line of best fit

1

extrapolation to meet the printed line

1

(f) 22.6 – 20.2

*allow ecf from question **(e)***

1

= 2.4 (°C)

ignore sign
*if no other mark awarded allow **1** mark for 2.2 (°C)*

1

(g) temperature of solution

1

[12]