

Name: \_\_\_\_\_

# Energy Changes part 1 AQA Triple Chemistry

Class: \_\_\_\_\_

Date: \_\_\_\_\_

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Time: **75 minutes**

Marks: **69 marks**

Comments:

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1.

Metals react with acids to produce a salt and a gas.

(a) Which salt is produced when magnesium reacts with hydrochloric acid?

Tick (✓) **one** box.

Magnesium chloride

Magnesium nitrate

Magnesium sulfate

(1)

(b) Which gas is produced when magnesium reacts with hydrochloric acid?

Tick (✓) **one** box.

Carbon dioxide

Chlorine

Hydrogen

Oxygen

(1)

A student investigated the temperature change in the reaction between metals and hydrochloric acid.

This is the method used.

1. Measure 25 cm<sup>3</sup> of hydrochloric acid at 20 °C into a container.
2. Add 1 g of a metal.
3. Record the temperature change.
4. Repeat steps 1 to 3 using a different metal.

(c) Draw **one** line from the type of variable to the name of the variable in the investigation.

Type of variable	Name of variable
Dependent variable	Mass of metal
	Temperature change
	Type of metal
Independent variable	Volume of hydrochloric acid

(2)

(d) Which container would be the most suitable to reduce energy transfer with the surroundings?

Tick (✓) **one** box.

A copper can

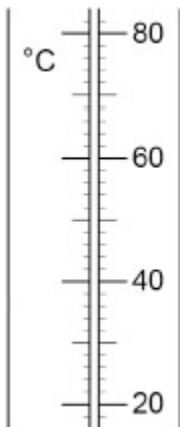
A glass beaker

A polystyrene cup

(1)

(e) **Figure 1** shows part of the scale of the thermometer used in the investigation.

**Figure 1**



What is the resolution of the thermometer?

Tick (✓) **one** box.

1 °C

2 °C

10 °C

20 °C

**(1)**

(f) The reaction between a metal and an acid is exothermic.

What happens to the temperature of the mixture during the reaction?

Tick (✓) **one** box.

Decreases

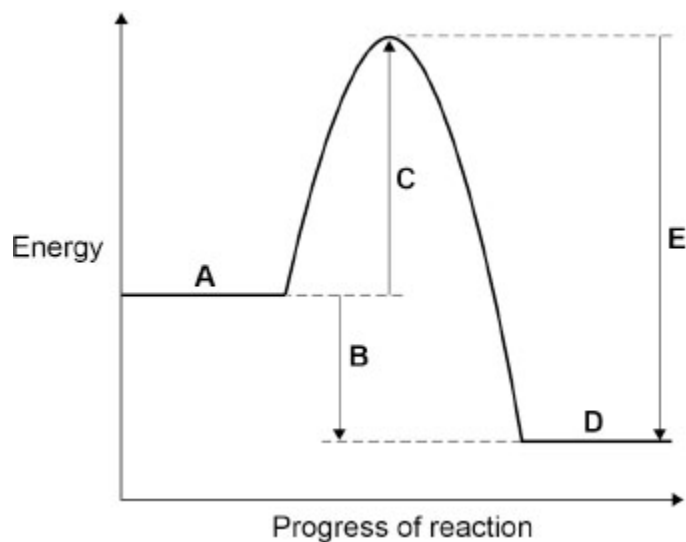
Stays the same

Increases

**(1)**

**Figure 2** shows the reaction profile for the reaction between a metal and an acid.

**Figure 2**



(g) Which letter in **Figure 2** represents the reactants?

Tick (✓) **one** box.

A       B       C       D       E

(1)

(h) Which letter in **Figure 2** represents the activation energy?

Tick (✓) **one** box.

A       B       C       D       E

(1)

(i) Which letter in **Figure 2** represents the overall energy change?

Tick (✓) **one** box.

A       B       C       D       E

(1)

(Total 10 marks)

**2.** Hydrazine (N<sub>2</sub>H<sub>4</sub>) is a compound of nitrogen and hydrogen.

(a) Scientists are researching the use of hydrazine in fuel cells.

**Table 1** gives some information about the use of hydrogen and hydrazine in fuel cells.

	<b>Hydrogen</b>	<b>Hydrazine</b>
State at room temperature	Gas	Liquid
Hazards	Explosive	Toxic
Equation for fuel cell reaction	$2 \text{H}_2 + \text{O}_2 \rightarrow 2 \text{H}_2\text{O}$	$\text{N}_2\text{H}_4 + \text{O}_2 \rightarrow \text{N}_2 + 2 \text{H}_2\text{O}$
Voltage produced in volts	1.23	1.61
Catalyst needed for reaction	Platinum	None

Evaluate the use of hydrazine instead of hydrogen in a fuel cell.

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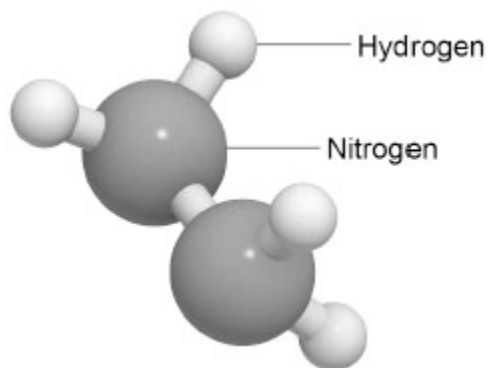
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**(4)**

Figure 1 shows a model of the hydrazine molecule.

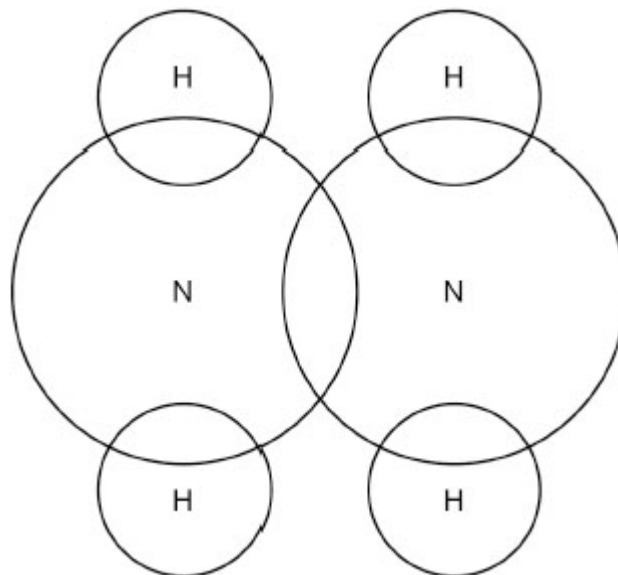
Figure 1



(b) Complete the dot and cross diagram for hydrazine in Figure 2.

Show the outer shell electrons only.

Figure 2



(2)

(c) Give **one** advantage of the ball and stick model in Figure 1 compared to the dot and cross diagram.

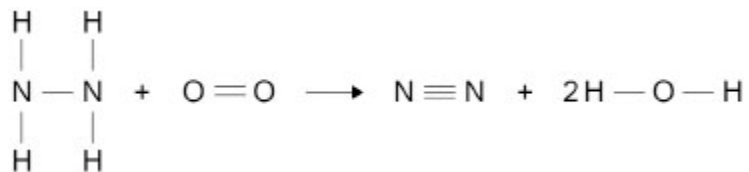
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(1)

- (d) **Figure 3** shows the displayed formula equation for the reaction of hydrazine with oxygen.

**Figure 3**



The reaction is exothermic.

The energy released forming new bonds is 581 kJ/mol greater than the energy needed to break existing bonds.

**Table 2** shows some bond energies.

**Table 2**

Bond	N — N	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	X	391	498	945	464

Calculate the bond energy (X) of the N — N bond.

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X = \_\_\_\_\_ kJ/mol

(4)

(Total 11 marks)

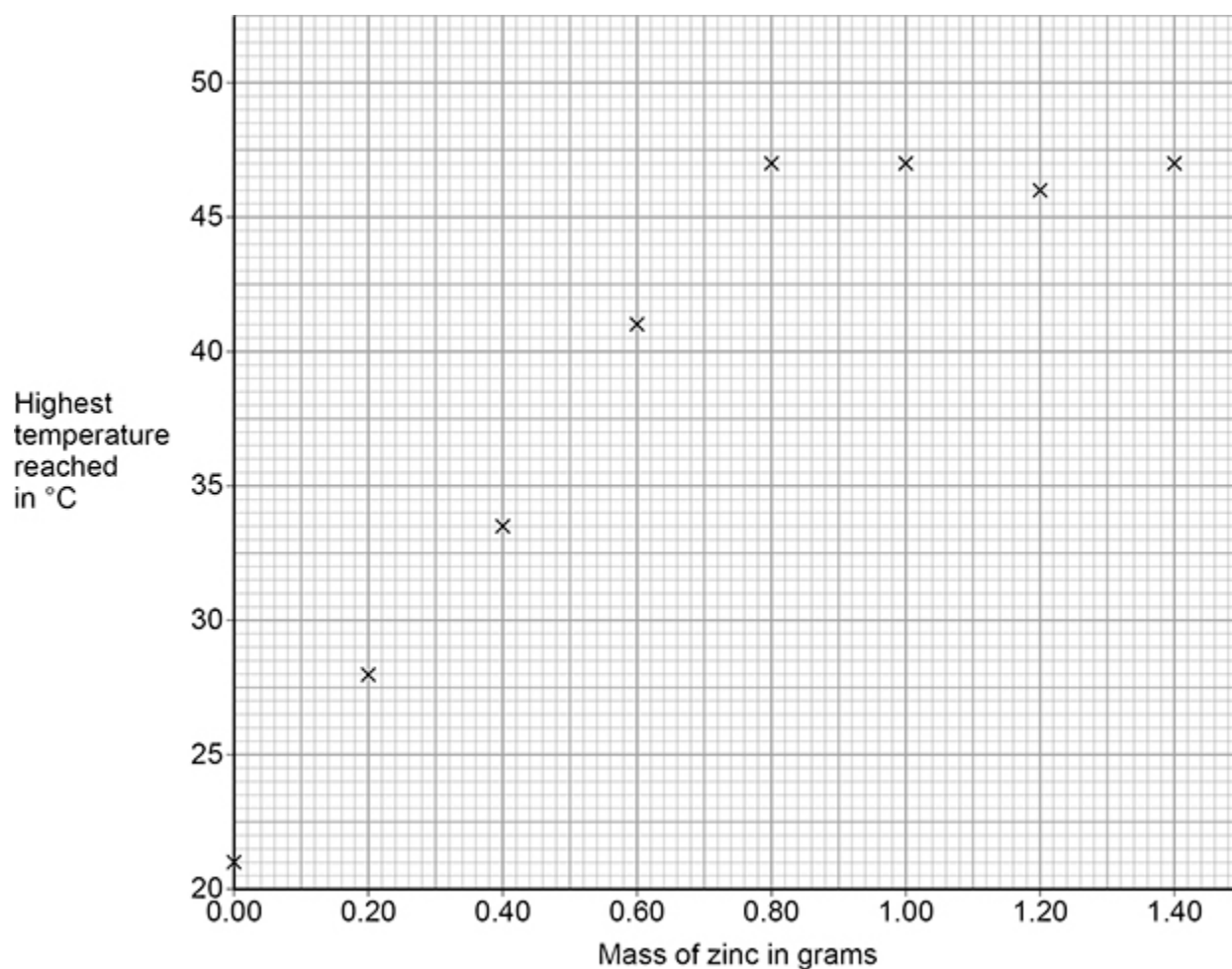
3.

A student investigated the energy change of the reaction between zinc and copper sulfate solution.

This is the method used.

1. Measure 25 cm<sup>3</sup> of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of the copper sulfate solution.
3. Add 0.20 g of zinc powder to the copper sulfate solution.
4. Stir the reaction mixture.
5. Record the highest temperature reached.
6. Repeat steps 1 to 5 with different masses of zinc powder.

The figure below shows the results.



- (a) Draw **two** lines of best fit on the figure above.

The lines should cross.

(2)

(b) Explain the results shown in above figure.

Do **not** refer to anomalous points.

Use data from the figure above.

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(4)

(c) Explain why using a polystyrene cup gives more accurate results than using a glass beaker.

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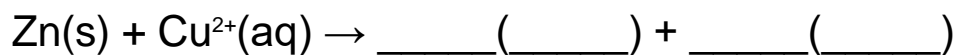
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(2)

(d) Complete the ionic equation for the reaction between zinc and copper sulfate solution.

Include state symbols.



(2)

A different student repeated steps 1 to 5 of the method four times using 0.50 g of zinc powder.

The table below shows the results.

	<b>Trial 1</b>	<b>Trial 2</b>	<b>Trial 3</b>	<b>Trial 4</b>
<b>Highest temperature reached in °C</b>	37.6	37.2	37.8	37.4

(e) Calculate the mean highest temperature reached.

Include the uncertainty in your answer.

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Mean highest temperature reached = \_\_\_\_\_  $\pm$  \_\_\_\_\_  $^{\circ}\text{C}$

(3)

(f) The results show random errors.

The student did not make any measuring errors.

Suggest **one** reason for the random errors in this experiment.

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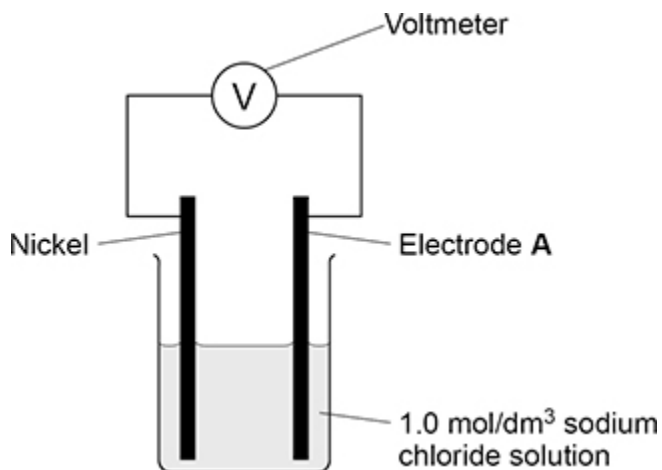
(1)

(Total 14 marks)

4.

A student investigated the voltage produced by different pairs of metal electrodes in a chemical cell.

The figure below shows the apparatus.



This is the method used.

1. Place a nickel electrode and an electrode made from a different metal (electrode **A**) in 1.0 mol/dm<sup>3</sup> sodium chloride solution.
2. Measure the voltage produced.
3. Repeat using different metals for electrode **A**.

The table below shows the results.

Electrode A	Symbol of metal	Voltage in volts
Copper	Cu	-0.59
Magnesium	Mg	2.12
Nickel	Ni	0.00
Silver	Ag	-1.05
Zinc	Zn	0.51

(a) Write the symbols of the five metals in the above table in order of reactivity.

Justify your answer.

Most reactive \_\_\_\_\_ Least reactive

Justification \_\_\_\_\_

\_\_\_\_\_

(3)



**5.**

This question is about hydrogen and compounds of hydrogen.

**Figure 1** shows the displayed formulae for the reaction between hydrogen and chlorine.

**Figure 1**



The table below shows the bond energies.

Bond	H—H	Cl—Cl	H—Cl
Bond energy in kJ/mol	436	346	432

- (a) Which expression shows how to calculate the overall energy change for the reaction in **Figure 1**?

Use the table above.

Tick (✓) **one** box.

436 + 346 + 432 kJ/mol

436 + 346 + (2 × 432) kJ/mol

436 + 346 - 432 kJ/mol

436 + 346 - (2 × 432) kJ/mol

(1)

The reaction between hydrogen and chlorine is exothermic.

- (b) Explain why this reaction releases energy to the surroundings.

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(2)

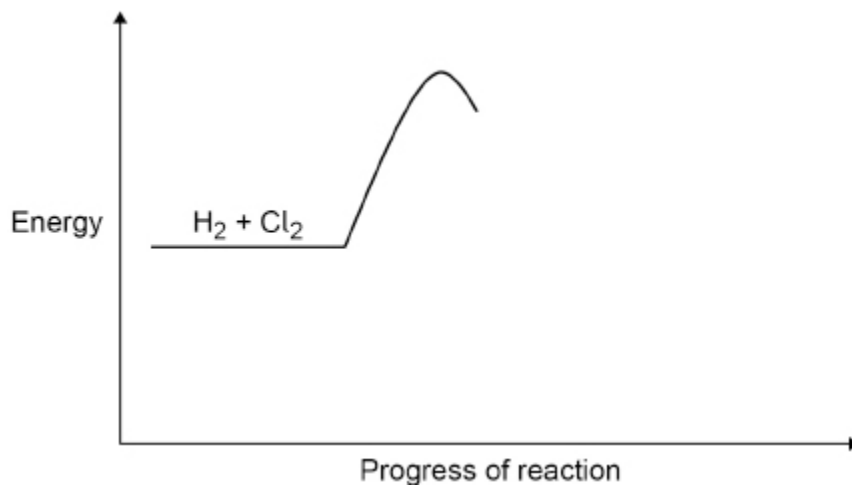
(c) **Figure 2** shows part of a reaction profile for the reaction between hydrogen and chlorine.

Complete the reaction profile in **Figure 2**.

You should:

- label the activation energy
- label the overall energy change.

**Figure 2**



(3)

(d) Draw a dot and cross diagram for a molecule of hydrogen chloride (HCl).

Show the outer shell electrons only.

(2)

(e) **Figure 3** represents molecules of methane and of poly(ethene).

**Figure 3**



Methane is a gas at room temperature but poly(ethene) is a solid at room temperature.

Explain why methane and poly(ethene) exist in different states at room temperature.

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(4)

(Total 12 marks)

6.

This question is about temperature changes.

A student investigated the change in temperature of a solution when different masses of ammonium nitrate were dissolved in water.

This is the method used.

1. Measure 200 cm<sup>3</sup> of water into a polystyrene cup.
2. Measure the temperature of the water.
3. Add 4.0 g of ammonium nitrate to the water.
4. Stir the solution until all the ammonium nitrate has dissolved.
5. Measure the lowest temperature reached by the solution.
6. Repeat steps 1 to 5 with different masses of ammonium nitrate.

(a) Give the independent variable and the dependent variable in the investigation.

Independent variable \_\_\_\_\_

Dependent variable \_\_\_\_\_

(2)

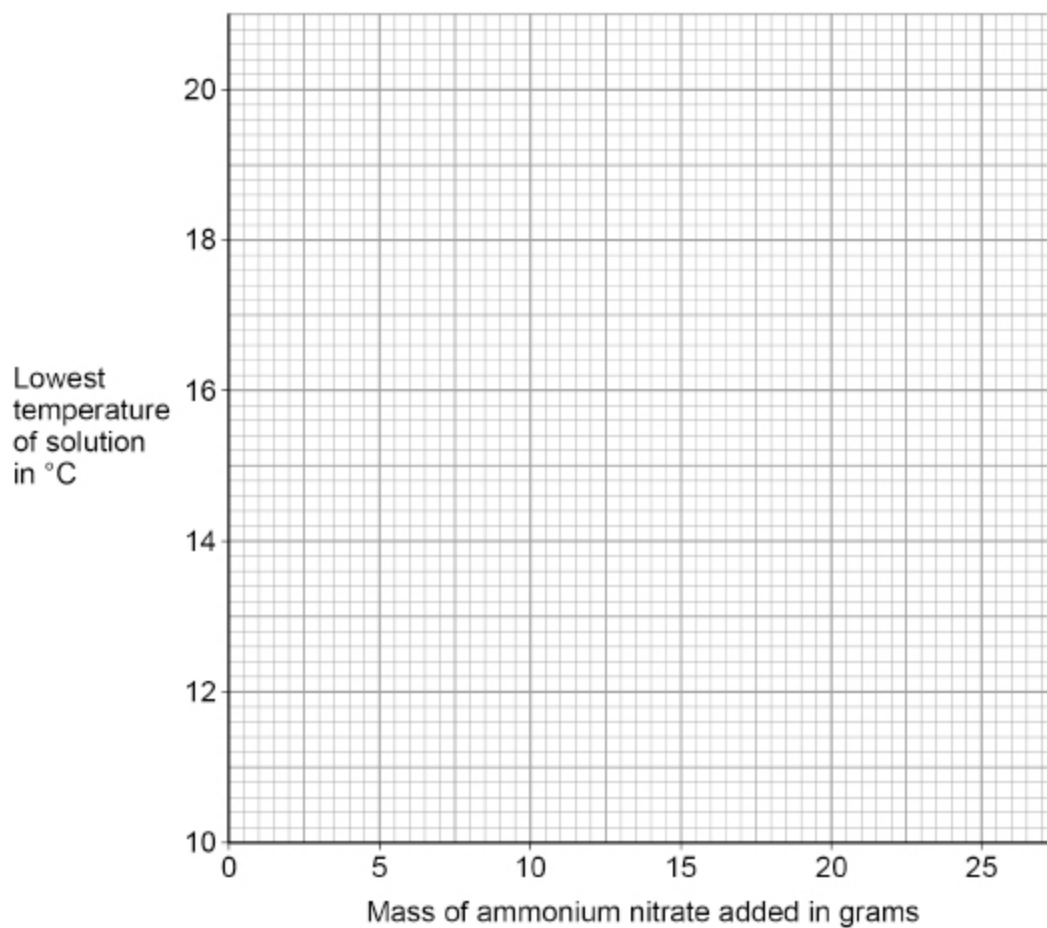
Table 1 shows the results.

Table 1

Mass of ammonium nitrate added in grams	Lowest temperature of solution in °C
4.0	18.2
8.0	16.2
12.0	15.2
16.0	13.6
20.0	12.4
24.0	10.6

(b) Plot the data from Table 1 on the graph below.

Draw a line of best fit.



(3)

(c) Determine the initial temperature of the water.

You should extend your line of best fit on the graph above.

Initial temperature of the water = \_\_\_\_\_ °C

(2)

(d) How do the results show that dissolving ammonium nitrate in water is endothermic?

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(1)

The student repeated the experiment three more times.

**Table 2** shows the results for 8.0 g of ammonium nitrate.

**Table 2**

	<b>Trial 1</b>	<b>Trial 2</b>	<b>Trial 3</b>	<b>Trial 4</b>	<b>Mean</b>
<b>Lowest temperature of solution in °C</b>	16.2	16.6	16.8	16.4	16.5

(e) The student recorded the mean lowest temperature of the solution for 8.0 g of ammonium nitrate as  $16.5 \pm 0.3$  °C.

Explain why the student included  $\pm 0.3$  °C after the mean lowest temperature.

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(2)

(f) What type of error is shown by the results in **Table 2**?

Tick (✓) **one** box.

Random error

Systematic error

Zero error

(1)  
(Total 11 marks)

## Mark schemes

1.

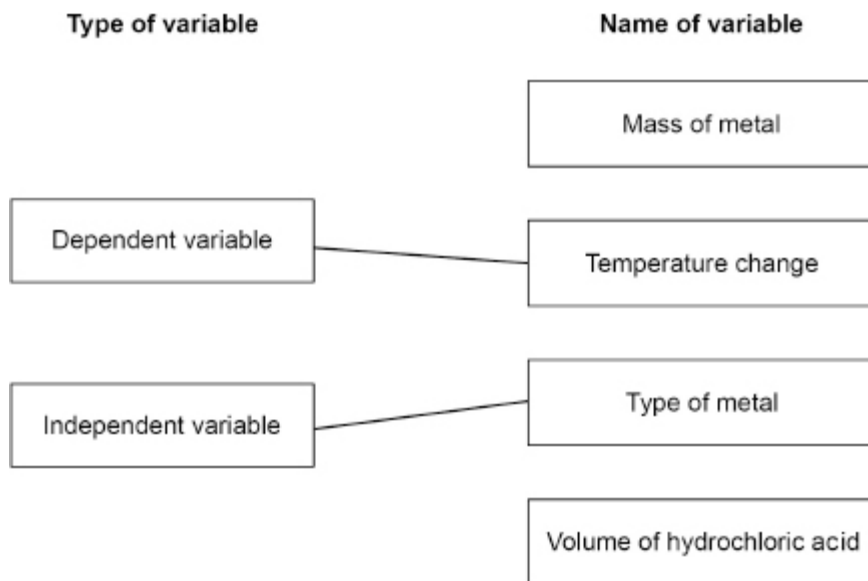
(a) magnesium chloride

1

(b) hydrogen

1

(c)



do **not** accept more than one line from a box on the left

2

(d) a polystyrene cup

1

(e) 2 °C

1

(f) increases

1

(g) **A**

1

(h) **C**

1

(i) **B**

1

**[10]**

2.

- (a) **Level 2:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.

3-4

**Level 1:** Some logically linked reasons are given. There may also be a simple judgement.

1-2

**No relevant content**

0

**Indicative content**

- hydrazine is liquid so easier to store / transport
  - because takes up less space
- both have significant dangers
- both produce harmless products
- hydrazine produces a higher voltage so fewer cells will be needed (to produce the same voltage)
  - so the battery would be lighter
- hydrazine needs no catalyst so costs may be less
- hydrogen uses platinum as a catalyst which is a rare metal
- judgement

- (b) bonded pair of electrons in each overlap

*allow any combination of x, o, e<sup>(-)</sup>, l for electrons*

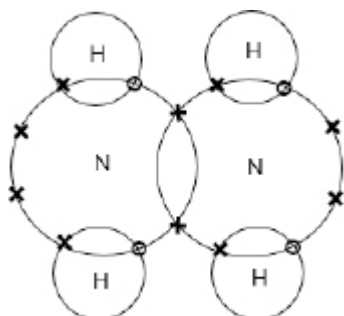
1

each nitrogen atom with 2 non-bonded electrons

*do **not** accept if extra electrons on hydrogen atom(s)*

*MP2 is dependent upon the award of MP1*

*an answer of*



*scores 2 marks*

1

- (c) (the ball and stick model) shows the shape (of the molecule)  
**or**  
(the ball and stick model) is 3-D

1

- (d) (bonds broken =  
 $(4 \times 391) + 498 + X =$   
 $2062 + X$  1
- (bonds formed =  
 $945 + (4 \times 464) =$   
 $2801$  1
- $581 = 2801 - (2062 + X)$   
*allow correct use of incorrectly determined values of bonds broken  
and / or bonds made* 1
- $(X =) 158$  (kJ/mol) 1

[11]

- 3.** (a) line of best fit using the first five points  
*max 1 mark if the lines do not intersect* 1
- line of best fit using the last four points 1
- (b) the temperature rises because the reaction is exothermic  
**or**  
the temperature rises because energy is transferred to the surroundings  
*allow heat for energy* 1
- until 0.8 g (zinc) is added  
*allow a tolerance of  $\pm \frac{1}{2}$  a small square  
allow until the temperature reaches  $47^\circ\text{C}$   
allow a correctly determined value for mass of zinc or temperature  
from the intersection of drawn lines of best fit* 1
- (so) there is no additional reaction  
*allow (when) the reaction has finished* 1
- (because) zinc is in excess  
**or**  
(because) copper sulfate is used up 1

(c) polystyrene is a better (thermal) insulator  
*allow converse statements for glass* 1

(so) there is less energy transfer to the surroundings  
*allow (so) less energy is lost (to the surroundings)*  
*allow heat for energy* 1

(d)  $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Cu(s)}$   
allow 1 mark for  $\text{Zn}^{2+} + \text{Cu}$  2

(e) (mean highest temperature =)  
$$\frac{37.6 + 37.2 + 37.8 + 37.4}{4}$$
*allow*  
(mean highest temperature =)  $\frac{150}{4}$  1

= 37.5 (°C) 1

37.5 (°C) ± 0.3 (°C) 1

(f) any **one** from:  
• starting temperature may be different  
*ignore room temperature*  
• inconsistent stirring  
*allow inconsistent use of a lid* 1

[14]

4.

(a) (most reactive)

Mg Zn Ni Cu Ag

(least reactive)

*allow name of metal for symbol*

*allow 1 mark for*

*(most reactive)*

*Mg Zn Ni*

**or**

*Ni Cu Ag*

*(least reactive)*

2

(justification)

the higher the (positive) voltage the more reactive the metal

*allow the most reactive (metal) has the highest (positive) voltage*

*allow the least reactive (metal) has the most negative voltage*

*allow the greater the difference in reactivity the greater the  
(magnitude of the) voltage*

1

(b) **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 method is not fully logically sequenced.

3-4

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

1-2

**No relevant content**

0

**Indicative content**

- **set up cell with sodium chloride solution as the electrolyte**
- **use two different metals as electrodes**
  
- **measure voltage**
  
- **repeat at different concentrations of electrolyte solution**
- **by diluting the sodium chloride solution with water**
  
- using measured volumes of sodium chloride solution and water
- measure volumes with a measuring cylinder (allow pipette / burette)
  
- use the same two metals each time
  
- use the same volume of electrolyte solution

- (c) hydrogen is oxidised (electrochemically)  
*ignore references to electrodes*  
*allow hydrogen loses electrons*

1

to produce water

1

[11]

5.

- (a)  $436 + 346 - (2 \times 432)$  kJ/mol

1

- (b) energy is needed to break bonds  
**and**  
 energy is released when bonds form

1

(and) the energy released is greater than the energy needed

*allow the energy transferred in bond making is greater than the energy transferred in bond breaking*

*allow  $2 \times 432$  (kJ/mol) is greater than  $436 + 346$  (kJ/mol)*

*allow the overall energy change is negative*

1

- (c) profile completed with product energy below reactant energy

1

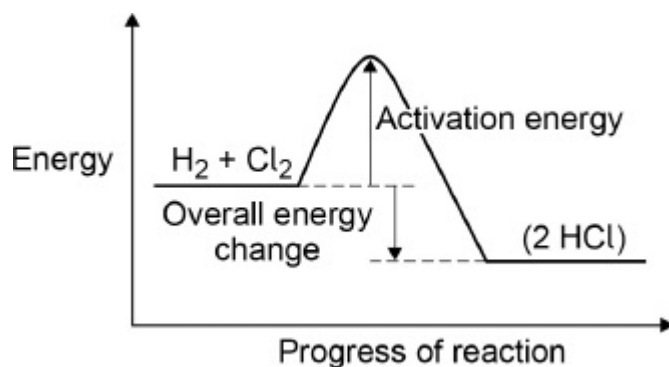
activation energy labelled from reactant energy to top of curve

1

overall energy change labelled from reactant energy to product energy

1

an answer of



scores 3 marks

*ignore arrow heads*

(d) bonded pair of electrons in the overlap

*allow any combination of x, o, e<sup>(-)</sup>, \* for electrons*

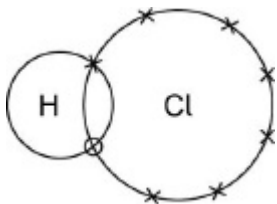
*do **not** accept molecules containing more than 2 atoms*

1

chlorine with 6 non-bonded electrons

*do **not** accept if extra electrons on H*

*an answer of*



*scores **2** marks*

**or**

*an answer of*



*scores **2** marks*

1

(e) (methane)

methane has (much) smaller molecules

1

(so) has weaker intermolecular forces

*do **not** accept reference to weak(er) covalent bonds*

1

(so the intermolecular forces) need less energy to overcome

*do **not** accept reference to breaking covalent bonds*

1

(so) the boiling / melting point is lower (and methane is a gas)

1

OR

(poly(ethene))

poly(ethene) has (much) larger molecules (1)

(so) has stronger intermolecular forces (1)

*do not accept reference to weak(er) covalent bonds*

(so the intermolecular forces) need more energy to break (1)

*do not accept reference to breaking covalent bonds*

(so) the melting / boiling point is higher (and poly(ethene) is a solid) (1)

[12]

6.

- (a) (independent variable)  
mass (of ammonium nitrate)

1

(dependent variable)

(lowest) temperature (reached by solution)

*allow change in temperature (of solution)*

1

- (b) all 6 points plotted correctly

*allow a tolerance of  $\pm \frac{1}{2}$  a small square*

2

*allow 1 mark for 4 or 5 points plotted correctly*

line of best fit

1

- (c) line extrapolated to y-axis

1

(initial temperature)

value for temperature where extrapolated line meets y-axis

*allow a tolerance of  $\pm \frac{1}{2}$  a small square*

1

- (d) temperature decreased

*ignore correct references to energy transfer*

1

(e) (0.3 °C) is the uncertainty

1

(because 0.3 °C) is the range about the mean value

*allow values are (a maximum of) 0.3 (°C) either side of the mean*

*allow (because)*

$$16.8 = 16.5 + 0.3$$

**and**

$$16.2 = 16.5 - 0.3$$

1

(f) random error

1

[11]