Energy Changes part 3 AQA Triple Chemistry

Name: ____________________

Class: ____________________

Date: ____________________

Time: **91 minutes**

Marks: **86 marks**

Comments:

1. This question is about citric acid ($C_6H_8O_7$).

Citric acid is a solid.

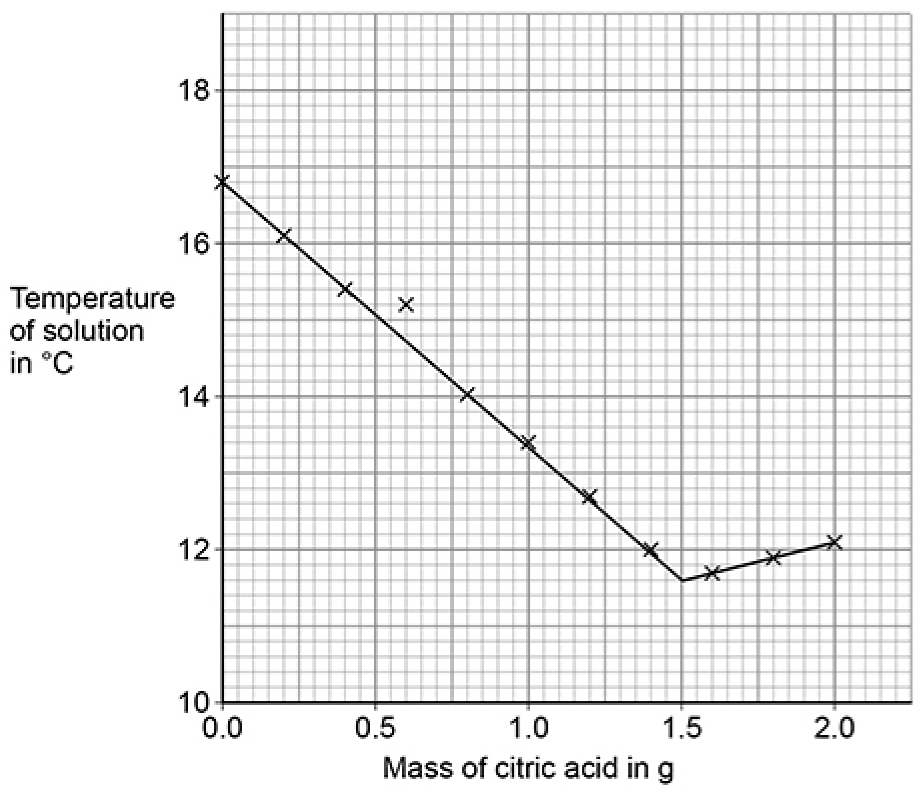
A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

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 0.20 g of citric acid to the polystyrene 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 student plotted the results on a graph.

The student's graph is shown below.



(a) The graph shows an anomalous point when 0.60 g of citric acid was added. This was caused by the student making an error.

The student correctly:

- measured the mass of the citric acid
- read the thermometer
- plotted the point.

Suggest **one** reason for the anomalous point.

____

____

(1)

(b) Explain the shape of the graph in terms of the energy transfers taking place.

You should use data from the graph above in your answer.

____

____

____

____

____

____

(3)

(c) A second student repeated the investigation using a metal container instead of the polystyrene cup. The container and the cup were the same size and shape.

Sketch a line on above graph to show the second student's results until 1.00 g of citric acid had been added. The starting temperature of the solution was the same.

Explain your answer.

____

____

____

____

(3)

The student used a solution of citric acid to determine the concentration of a solution of sodium hydroxide by titration.

(d) The student made 250 cm^3 of a solution of citric acid of concentration 0.0500 mol/dm^3

Calculate the mass of citric acid ($C_6H_8O_7$) required.

Relative atomic masses (A_r): H = 1 C = 12 O = 16

____

____

____

____

____

Mass = ______________ g

(3)

This is part of the method the student used for the titration.

1. Measure 25.0 cm^3 of the sodium hydroxide solution into a conical flask using a pipette.
2. Add a few drops of indicator to the flask.
3. Fill a burette with citric acid solution.

(e) Describe how the student would complete the titration.

____

____

____

____

____

____

(3)

(f) Give **two** reasons why a burette is used for the citric acid solution.

1 ____

____

2 ____

____

(2)

(g) 13.3 cm^3 of 0.0500 mol/dm^3 citric acid solution was needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

The equation for the reaction is:

$$3\ NaOH + C_6H_8O_7 \rightarrow C_6H_5O_7Na_3 + 3\ H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm^3

Concentration = ______________ mol/dm^3

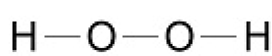
(3)

(Total 18 marks)

2. This question is about compounds of oxygen and hydrogen.

Figure 1 represents the structure of hydrogen peroxide.

Figure 1



(a) What is the correct formula of hydrogen peroxide?

Tick (✓) **one** box.

H2O2 ☐

HO_2 ☐

H^2O^2 ☐

H_2O_2 ☐

(1)

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

Tick (✓) **one** box.

Covalent ☐

Ionic ☐

Metallic ☐

(1)

(c) Hydrogen peroxide decomposes in the presence of a catalyst.

Which elements are often used as catalysts?

Tick (✓) **one** box.

Alkali metals ☐

Halogens ☐

Transition metals ☐

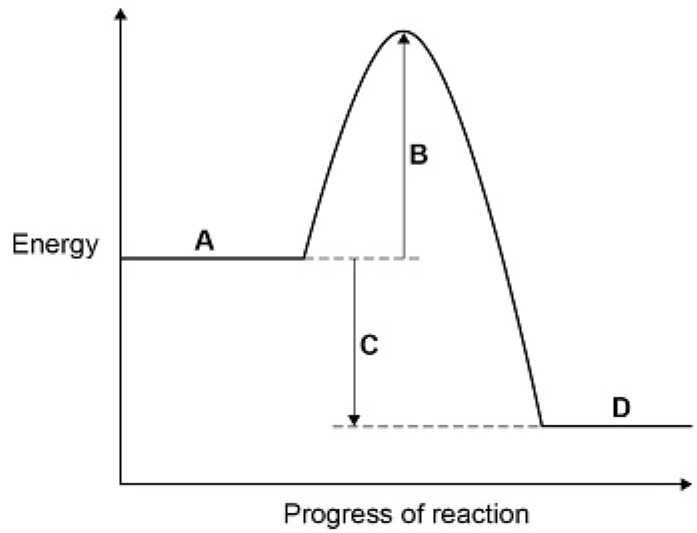
(1)

Figure 2 shows the reaction profile for the decomposition of hydrogen peroxide.

The word equation for this reaction is:

hydrogen peroxide → water + oxygen

Figure 2



Labels **A**, **B**, **C** and **D** each represent a different part of the reaction profile.

Use **Figure 2** to answer parts (d) and (e).

(d) Which label shows the activation energy?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(e) Which label shows the energy of hydrogen peroxide?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(f) The decomposition of hydrogen peroxide gives out energy to the surroundings.

What type of reaction is this?

Tick (✓) **one** box.

Displacement ☐

Endothermic ☐

Exothermic ☐

Neutralisation ☐

(1)

(g) Hydrogen and oxygen form water.

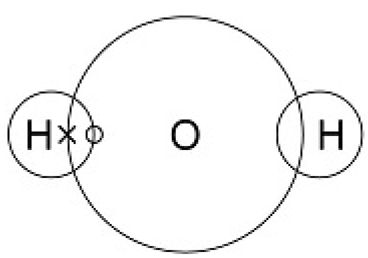
A hydrogen atom contains one electron.

An oxygen atom contains six electrons in the outer shell.

Complete **Figure 3** to show a dot and cross diagram for a water molecule.

Show the outer electrons only.

Figure 3



(2)

(Total 8 marks)

3. This question is about energy changes in reactions.

(a) Ammonium nitrate dissolves in water.

The change is endothermic.

Which piece of equipment uses this change?

Tick (✓) **one** box.

Hand warmer	☐
Self-heating can	☐
Sports injury pack	☐

(1)

A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25 cm^3 of potassium hydroxide solution into a glass beaker.

2. Add 5 cm^3 of dilute sulfuric acid.

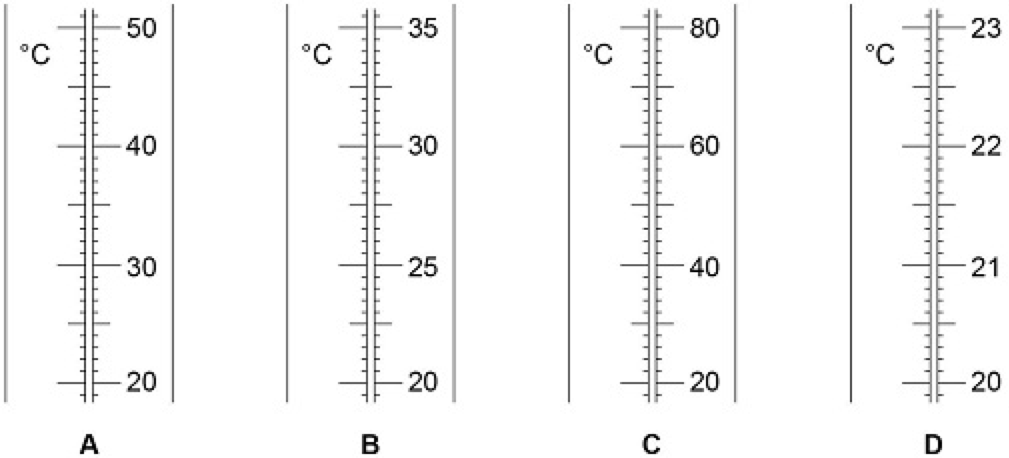
3. Stir the solution.

4. Measure the temperature of the solution.

5. Repeat steps 2 to 4 until a total of 30 cm^3 of dilute sulfuric acid has been added.

(b) **Figure 1** shows part of the scales of four thermometers, **A**, **B**, **C** and **D**.

Figure 1



The student wanted to measure the temperature to a resolution of 0.1 °C

Which thermometer should the student use?

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

(1)

(c) Energy is lost to the surroundings during the reaction.

What type of error does this cause in the results?

(1)

Tick (✓) **one** box.

Human error ☐

Random error ☐

Systematic error ☐

Zero error ☐

(1)

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

Name a container the student could use instead of the glass beaker to improve the accuracy of the results.

____

____

(1)

(e) The following table shows the student's results.

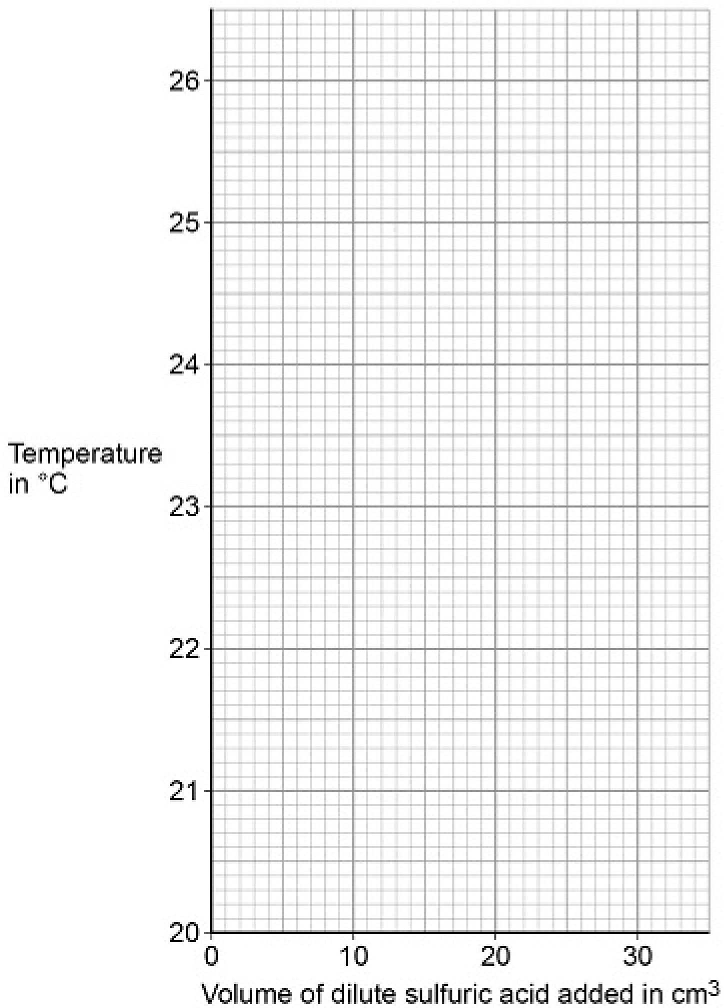
Volume of dilute sulfuric acid added in cm^3	**Temperature in °C**
5	21.2
10	22.0
15	22.8
20	23.6
25	24.4
30	25.2

Plot the data from the table on **Figure 2**.

You should:

- draw a line of best fit
- extend your line of best fit to the y-axis.

Figure 2



(4)

(f) The intercept on the y-axis of **Figure 2** shows the starting temperature of the potassium hydroxide solution.

Give the starting temperature of the potassium hydroxide solution.

Starting temperature = ________________________°C

(1)

(g) Another student repeated the investigation and obtained an anomalous result.

This result was lower than expected.

What could have caused the anomalous result?

Tick (✓) **two** boxes.

The mixture was not stirred.	☐
The temperature in the room increased.	☐
The thermometer was not accurate.	☐
Too little sulfuric acid was added.	☐
Too much potassium hydroxide solution was used.	☐

(2)

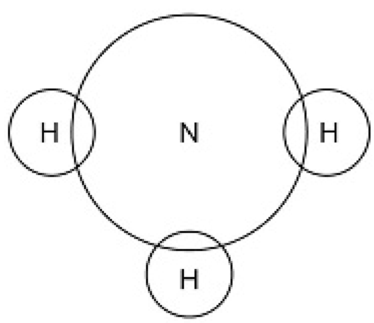
(Total 11 marks)

4. This question is about ammonia, NH_3

(a) Complete the dot and cross diagram for the ammonia molecule shown in **Figure 1**.

Show only the electrons in the outer shell of each atom.

Figure 1



(2)

(b) Give **one** limitation of using a dot and cross diagram to represent an ammonia molecule.

___

___

(1)

(c) Explain why ammonia has a low boiling point.

You should refer to structure and bonding in your answer.

____

____

____

____

____

____

(3)

Ammonia reacts with oxygen in the presence of a metal oxide catalyst to produce nitrogen and water.

(d) Which metal oxide is most likely to be a catalyst for this reaction?

Tick (✓) **one** box.

CaO ☐

Cr_2O_3 ☐

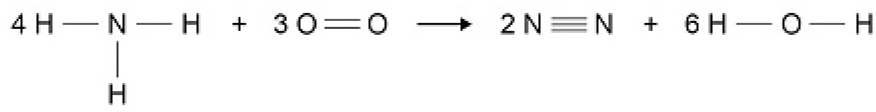
MgO ☐

Na_2O ☐

(1)

Figure 2 shows the displayed formula equation for the reaction.

Figure 2



The table shows some bond energies.

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

(e) Calculate the overall energy change for the reaction.

Use **Figure 2** and the table.

Overall energy change = ______________________ kJ/mol

(3)

(f) Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in part (e).

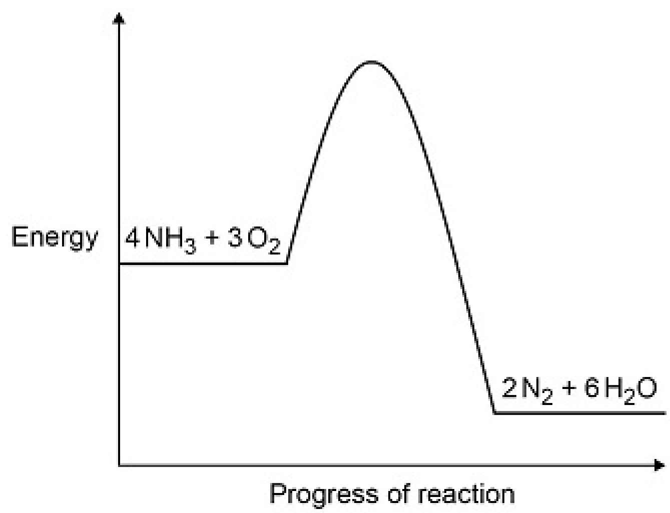
(2)

(g) **Figure 3** shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 3** by labelling the:

- activation energy
- overall energy change.

Figure 3



(2)

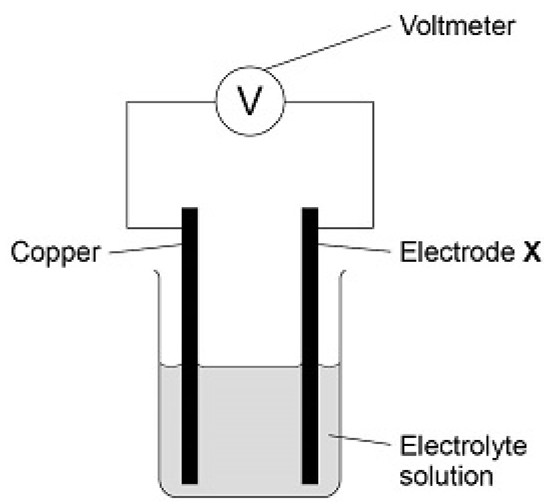
(Total 14 marks)

5. This question is about chemical cells.

A student investigated the voltage produced by different chemical cells.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Use cobalt as electrode **X**.

2. Record the cell voltage.

3. Repeat steps 1 and 2 using different metals as electrode **X**.

(a) Suggest **two** control variables used in this investigation.

1 ____

____

2 ____

____

(2)

The following table shows the student's results.

Electrode X	**Voltage of cell in volts**
cobalt	+0.62
copper	0.00
magnesium	+2.71
nickel	+0.59
silver	−0.46
tin	+0.48

(b) Write the six metals used for electrode **X** in order of reactivity.

Use the table above.

Justify your order of reactivity.

Most reactive ________________________________

____

____

____

____

Least reactive ________________________________

Justification ____

____

____

____

____

(4)

(c) Which of the following pairs of metals would produce the greatest voltage when used as the electrodes in the cell?

Use the table above.

Tick (✓) **one** box.

Magnesium and cobalt ☐

Magnesium and tin ☐

Nickel and cobalt ☐

Nickel and tin ☐

(1)

(d) Hydrogen fuel cells can be used to power different forms of transport.

Some diesel trains are being converted to run on hydrogen fuel cells.

A newspaper article referred to the converted trains as the new ‘steam trains’.

Suggest why.

____

____

____

____

(2)

(Total 9 marks)

6. A student investigated the temperature change in the reaction between dilute sulfuric acid and potassium hydroxide solution.

This is the method used.

1. Measure 25.0 cm^3 potassium hydroxide solution into a polystyrene cup.

2. Record the temperature of the solution.

3. Add 2.0 cm^3 dilute sulfuric acid.

4. Stir the solution.

5. Record the temperature of the solution.

6. Repeat steps 3 to 5 until a total of 20.0 cm^3 dilute sulfuric acid has been added.

(a) Suggest why the student used a polystyrene cup rather than a glass beaker for the reaction.

____

____

____

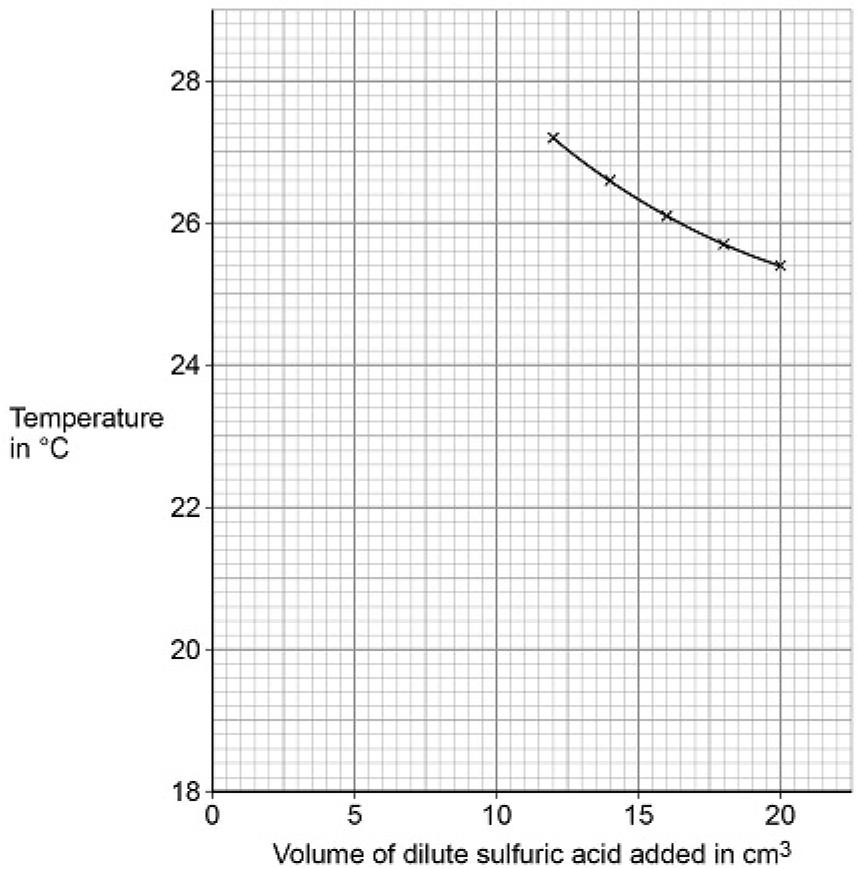
____

(2)

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

Volume of dilute sulfuric acid added in cm^3	Temperature in °C
0.0	18.9
2.0	21.7
4.0	23.6
6.0	25.0
8.0	26.1
10.0	27.1

The figure below shows some of the data from the investigation.



(b) Complete the figure:

- plot the data from the table
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

(4)

(c) Determine the volume of dilute sulfuric acid needed to react completely with 25.0 cm^3 of the potassium hydroxide solution.

Use the figure above.

Volume of dilute sulfuric acid to react completely = ______________________ cm^3

(1)

(d) Determine the overall temperature change when the reaction is complete.

Use the figure above.

____

____

Overall temperature change = __________________________ °C

(1)

(e) The student repeated the investigation.

The student used solutions that had different concentrations from the first investigation.

The student found that 15.5 cm^3 of 0.500 mol/dm^3 dilute sulfuric acid completely reacted with 25.0 cm^3 of potassium hydroxide solution.

The equation for the reaction is:

$$2\ KOH + H_2SO_4 \rightarrow K_2SO_4 + 2\ H_2O$$

Calculate the concentration of the potassium hydroxide solution in mol/dm^3 and in g/dm^3

Relative atomic masses (A_r): H = 1   O = 16   K = 39

____

____

____

____

____

____

____

____

____

____

____

____

Concentration in mol/dm^3 = ____________________ mol/dm^3

Concentration in g/dm^3 = ____________________ g/dm^3

(6)

(Total 14 marks)

7. A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

This is the method used.

1. Measure 50 cm^3 of the copper sulfate solution into a polystyrene cup.
2. Record the starting temperature of the copper sulfate solution.
3. Add the metal and stir the solution.
4. Record the highest temperature the mixture reaches.
5. Calculate the temperature increase for the reaction.
6. Repeat steps 1-5 with different metals.

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

Type of variable	Name of variable in the investigation
	Concentration of solution
Dependent variable	Particle size of solid
	Temperature change
Independent variable	Type of metal
	Volume of solution

(2)

(b) The student used a polystyrene cup and not a glass beaker.

Why did this make the investigation more accurate?

Tick **one** box.

Glass is breakable ☐

Glass is transparent ☐

Polystyrene is a better insulator ☐

Polystyrene is less dense ☐

(1)

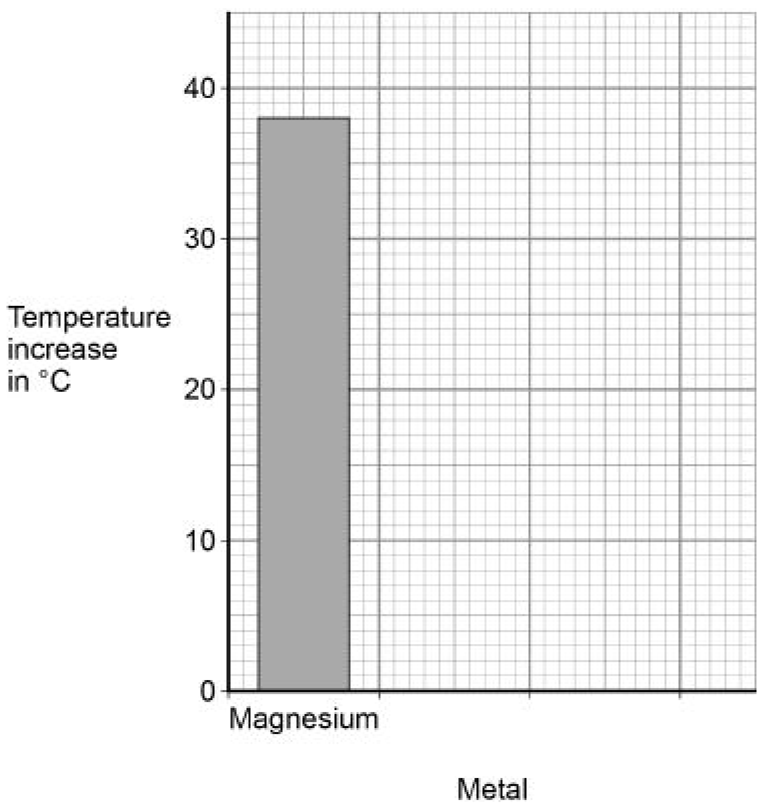
The table below shows the student's results.

Metal	**Temperature increase in °C**
Magnesium	38
Nickel	8
Zinc	16

(c) Complete **Figure 1**.

Use data from the table above.

Figure 1



(2)

(d) The student concluded that the reactions between the metals and copper sulfate solution are endothermic.

Give **one** reason why this conclusion is **not** correct.

____

____

(1)

(e) The temperature increase depends on the reactivity of the metal.

Write the metals magnesium, nickel and zinc in order of reactivity.

Use the table above.

Most reactive ___________________________

____

Less reactive ___________________________

(1)

(f) **Y** is an unknown metal.

Describe a method to find the position of **Y** in the reactivity series in Question **(e)**

____

____

____

____

____

____

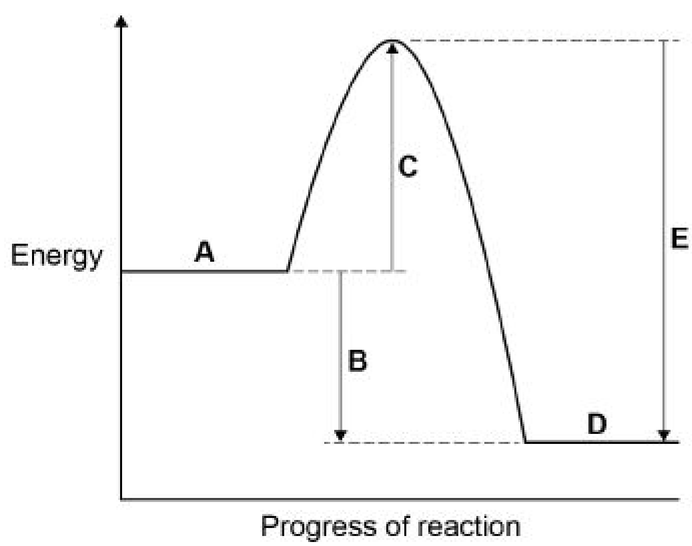
____

____

(3)

Figure 2 shows the reaction profile for the reaction between zinc and copper sulfate solution.

Figure 2



(g) Which letter represents the products of the reaction?

Tick **one** box.

A		B		C		D		E	

(1)

(h) Which letter represents the activation energy?

Tick **one** box.

A		B		C		D		E	

(1)

(Total 12 marks)

Mark schemes

1. (a) didn't stir (the solution enough)

allow measured the temperature before the temperature stopped falling
allow measured the temperature too soon

1

(b) the temperature decreases (initially) because energy is taken in (by the reaction from the solution)

allow temperature decreases (initially) because the reaction is endothermic

when 1.5 g (of citric acid) is added the sodium hydrogencarbonate has all reacted

allow when the temperature reaches 11.6 °C the sodium hydrogencarbonate has all reacted

or
from 1.5 g the citric acid is in excess

allow after the temperature reaches 11.6 °C the citric acid is in excess

or
when 1.5 g (of citric acid) is added the reaction is complete

allow when the temperature reaches 11.6 °C the reaction is complete

(so) the temperature increases as energy is transferred from the room to the solution

allow (so) the temperature increases as energy is transferred from the excess citric acid to the solution

1

(c) less steep line starting at 16.8 °C **and** reaching 1.00 g (of citric acid)

ignore any part of the line drawn beyond 1.00 g

1

(as) metal is a better conductor

allow (as) polystyrene is a better insulator

1

(so) more energy is absorbed (from the surroundings)

allow (so) more heat is absorbed (from the surroundings)

1

(d) (M_r citric acid =) 192

(moles = $\frac{250}{1000}$ × 0.0500) = 0.0125

(mass = 0.0125 × 192 =) 2.4 (g)

1

allow correct use of an incorrectly calculated M_r
allow correct use of an incorrectly calculated number of moles

1

alternative approach:

(M_r citric acid =) 192 (1)

(concentration = 0.0500 × 192)
= 9.6 (g/dm^3) (1)

allow correct use of an incorrectly calculated M_r

(mass = $\frac{250}{1000}$ × 9.6 =) 2.4 (g) (1)

allow correct use of an incorrectly calculated concentration in g/dm^3

(e) add the citric acid (to the flask) until there is a (permanent) colour change

ignore colours of indicator

1

measure / record the volume (of citric acid) added

allow take the final (and initial) burette reading

1

any **one** from:

- swirl
- use a white tile
- add the citric acid dropwise (near the end-point)
- repeat **and** calculate a mean

allow add the citric acid slowly (near the end-point)

1

(f) any **two** from:

- can add (the citric acid) in small increments

  allow can add (the citric acid) drop by drop

  allow can add (the citric acid) slowly

- can measure variable volumes

  allow has a scale 2

- more accurate than a measuring cylinder

2

(g) (moles citric acid = $\frac{13.3}{1000}$ × 0.0500) = 0.000665

1

(moles NaOH = 3 × 0.000665) = 0.001995

allow correct use of an incorrectly calculated number of moles of citric acid

1

(conc = $\frac{1000}{25}$ × 0.001995) = 0.0798 (mol/dm^3)

allow 0.08 or 0.080 (mol/dm^3)

allow correct use of an incorrectly calculated number of moles of NaOH

1

alternative approach:

$\frac{25.0 \times \text{conc NaOH}}{13.3 \times 0.0500} = \frac{3}{1}$ (1)

allow $\frac{13.3 \times 0.0500}{25.0 \times \text{conc NaOH}} = \frac{1}{3}$

(conc NaOH =) 3 × $\frac{13.3 \times 0.0500}{25.0}$ (1)

= 0.0798 (mol/dm^3) (1)

allow 0.08 or 0.080 (mol/dm^3)

[18]

2. (a) H_2O_2

1

(b) covalent

1

(c) transition metals

1

(d) B

1

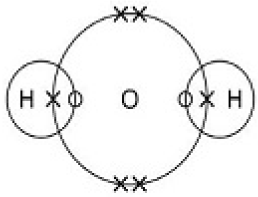
(e) A

1

(f) exothermic

1

(g)



*scores **2** marks*

allow dots, crosses, circles or e$^{(-)}$ for electrons

1 bonding pair of electrons in the right hand overlap

*do **not** accept any change to the number of electrons in the left hand overlap*

1

4 non-bonding electrons on oxygen

*do **not** accept non-bonding electrons on hydrogen*
ignore inner shell electrons drawn on oxygen

1

[8]

3. (a) sports injury pack

1

(b) D

1

(c) systematic error

1

(d) polystyrene cup

allow other insulating containers

1

(e) all six points plotted correctly

allow a tolerance of ± ½ a small square
*allow **1** mark for at least 3 points plotted correctly*

2

line of best fit

ignore extrapolation to y-axis

1

line extrapolated correctly to y-axis

1

(f) 20.4 (°C)

allow ecf from part (e)
allow a tolerance of ± ½ a small square

1

(g) the mixture was not stirred

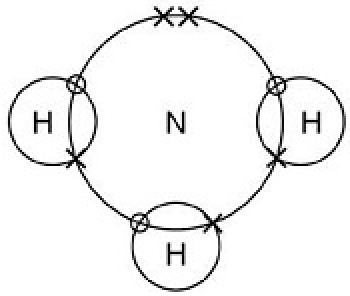
1

too little sulfuric acid was added

1

[11]

4. (a)



*scores **2** marks*

allow dots, crosses, circles or e$^{(-)}$ for electrons

1 bonding pair of electrons in each overlap

1

2 non-bonding electrons on nitrogen

*do **not** accept non-bonding electrons on hydrogen*

ignore inner shell electrons drawn on nitrogen

1

(b) does not show the shape
or
only two-dimensional

allow is not three-dimensional

1

(c) (ammonia has) small molecules

allow (ammonia has) a simple molecular (structure)

1

(ammonia has) weak intermolecular forces

allow (ammonia has) weak intermolecular bonds

*do **not** accept weak covalent bonds*

1

(so) little energy is needed to overcome the intermolecular forces

allow (so) little energy is needed to break the intermolecular bonds

allow (so) little energy is needed to separate the molecules

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

1

(d) Cr_2O_3

1

(e)

*an answer of (-)1272 (kJ) scores **3** marks*

(for bonds broken)
((12 x 391) + (3 x 498) =) 6186

1

(for bonds made)
((2 x 945) + (12 x 464) =) 7458

1

(overall energy change = 6186-7458 =) (-)1272 (kJ)

allow correct calculation using incorrectly calculated values from step 1 and/or step 2

1

(f)

allow ecf from part (e)

7458 (kJ) (released in making bonds) is greater than 6186 (kJ) (used in breaking bonds)
or
the products have 1272 (kJ) less energy than the reactants

allow the (overall) energy change is -1272 (kJ)

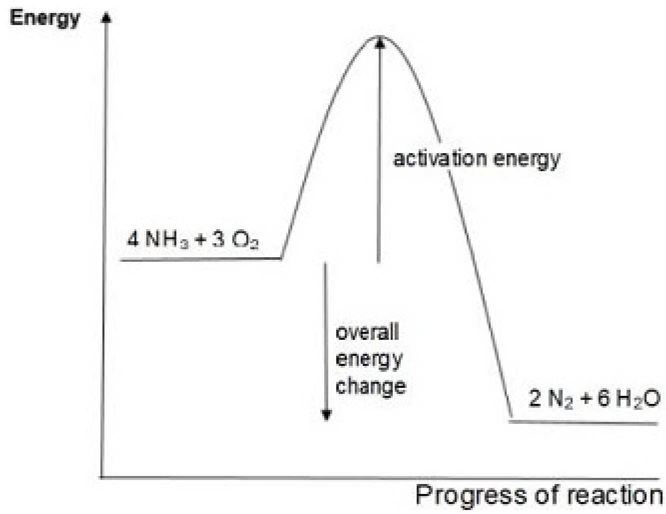
1

(so) energy is released (to the surroundings)

dependent on MP1 being awarded
allow (so) heat is released (to the surroundings)
*if no values given, allow **1** mark for more energy released in making bonds than used in breaking bonds*

1

(g)



*scores **2** marks*

allow discontinuous lines
ignore arrow heads

activation energy labelled

1

(overall) energy change labelled

1

[14]

5. (a) any **two** from:

- temperature (of solution)
  ignore room temperature
- concentration of electrolyte / solution
- compound / ions in electrolyte / solution

allow volume of electrolyte / solution

allow size of electrode

allow distance between electrodes

*do **not** accept electrode **X** unqualified*
*do **not** accept (measured) voltage*

2

(b) order:

(most reactive) magnesium
cobalt
nickel
tin
copper
(least reactive) silver

*allow **1** mark for magnesium, cobalt, nickel, tin in order at top*
*allow **1** mark for copper and silver in order at the bottom*

2

justification:
the higher the (positive) voltage, the more reactive (the metal)

allow the most reactive (metal) has the highest voltage

1

silver has a negative voltage because silver is less reactive than copper

1

(c) magnesium and tin

1

(d) (in a fuel cell) hydrogen is oxidised (to produce water)

allow (in a fuel cell) hydrogen reacts with oxygen (to produce water)

1

water is produced / released as gas / vapour / steam

*if no other mark awarded, allow **1** mark for fuel cells produce water*

1

[9]

6. (a) polystyrene is a better (thermal) insulator

allow polystyrene is a poorer (thermal) conductor

1

(so) reduces energy exchange (with the surroundings)

allow (so) reduces energy / heat loss (to the surroundings)

1

(b) all six points plotted correctly

allow a tolerance of ± ½ a small square
*allow **1** mark for at least 3 points plotted correctly*

2

line of best fit through points plotted from the table

1

both lines of best fit extrapolated correctly until they cross

1

(c) 11 (cm^3)

allow ecf from part (b)

allow answers in the range 10.75 to 11.25 (cm^3)

allow a tolerance of ± ½ a small square

1

(d) (27.5 − 18.9) = 8.6 (°C)

allow ecf from part (b)

allow answers in the range 8.5 to 8.7 (°C)

allow a tolerance of ± ½ a small square

1

(e)

*an answer of 0.62 (mol/dm^3) for concentration in mol/dm^3 scores **4** marks*

*an answer of 0.31 (mol/dm^3) for concentration in mol/dm^3 scores **3** marks*

(moles H_2SO_4 = 0.500 × $\frac{15.5}{1000}$) = 0.00775

1

(moles KOH = 2 x moles H_2SO_4 = 2 x 0.00775) = 0.0155

allow correct calculation using incorrectly calculated value of moles of H_2SO_4

1

(conc KOH = moles KOH x $\frac{1000}{25.0}$) = 0.0155 x $\frac{1000}{25.0}$)

allow correct calculation using incorrectly calculated value of moles of KOH

1

= 0.62 (mol/dm^3)

allow correct answer using incorrectly calculated value of moles of KOH

1

(M_r KOH =) 56

1

(conc = M_r x conc in mol/dm^3 = 56 x 0.62) = 34.7 (g/dm^3)

allow 35 or 34.72 (g/dm^3)

allow correct answer using incorrectly calculated value of concentration in mol/dm^3 and/or incorrect M_r

1

alternative approach for step 1 to step 4

$\frac{2}{1} = \frac{25 \times \text{conc KOH}}{15.5 \times 0.500}$ (2)

(conc KOH) $= \frac{2 \times 15.5 \times 0.500}{25.0}$ (1)

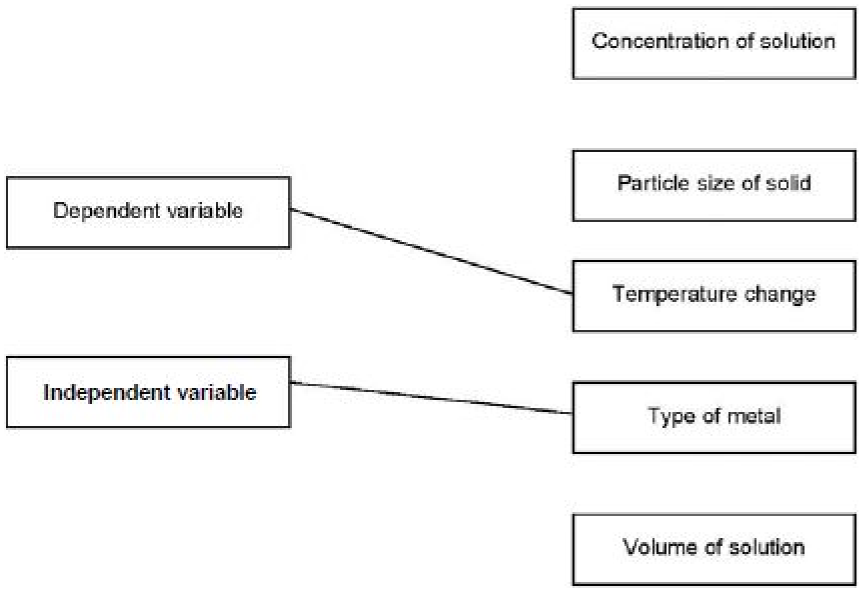
= 0.62 (mol/dm^3) (1)

allow 1 mark if mole ratio is incorrect

1

[14]

7. (a)



*allow **one** mark if answers are reversed*

1
1

(b) polystyrene is a better insulator

1

(c) both bars labelled

1

both bars correctly plotted

allow tolerance of ±½ small square

ignore width and spacing of bars

*if no other mark scored, allow **1** mark for any one bar correctly plotted and labelled*

1

(d) temperature increases

allow (because) energy / 'heat' is transferred to the surroundings

or

temperature does not decrease

energy / 'heat' is not taken in from the surroundings

allow the energy of the products is less than the energy of the reactants

1

(e) (most reactive)

magnesium

(zinc)

nickel

this order only

1

(f) suitable method described

1

the observations / measurements required to place in order

1

an indication of how results would be used to place the unknown metal in the reactivity series

1

approaches that could be used:

approach 1:
add the unknown metal to copper sulfate solution (1)

measure temperature change (1)

place the metals in order of temperature change (1)

approach 2:
add the metal to salt solutions of the other metals
or
heat the metal with oxides of the other metals (1)

measure temperature change (only if salt solutions used)
or
observe whether a chemical change occurs (1)

compare temperature change or whether there is a reaction to place in correct order (1)

approach 3:
add all of the metals to an acid (1)

measure temperature change or means of comparing rate of reaction (1)

place the metals in order of temperature change or rate of reaction (1)

approach 4:
set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1)

measure the voltage of the cell (1)

place the metals in order of voltage (1)

(g) D

1

(h) C

1

[12]