Questions are for both separate science and combined science students unless indicated in the question

Q1.

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.

_____

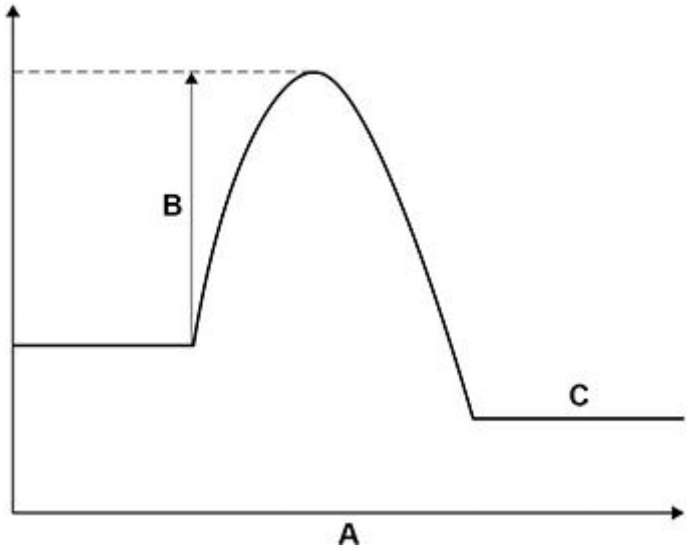
_____

_____

_____

(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)

Q2.

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.

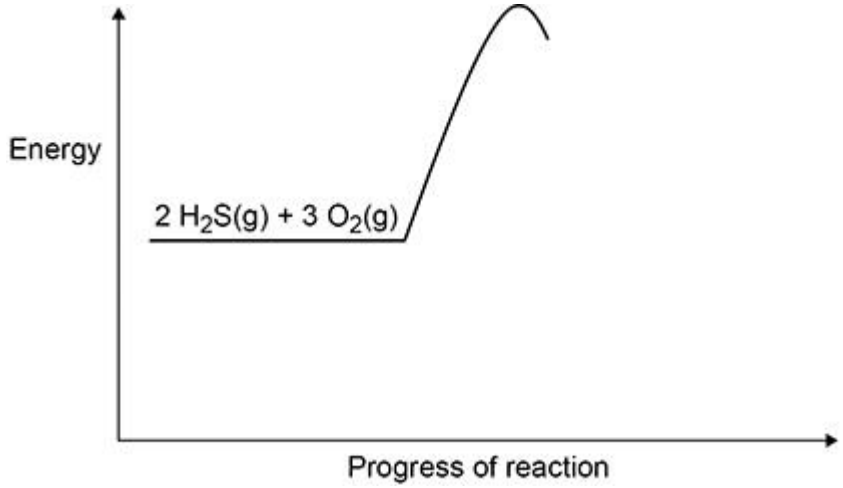
The reaction is exothermic.

Complete **Figure 1**.

You should:

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

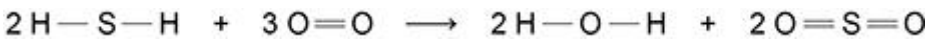
Figure 1



(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)

Q3.

This question is about chemical reactions and energy.

Hydrogen reacts with oxygen to produce water.

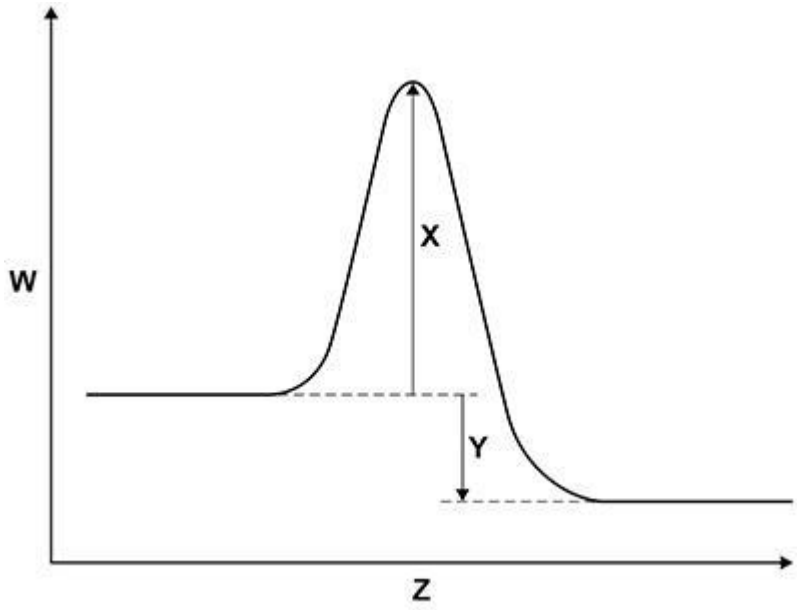
This reaction releases energy.

(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. **(separate only)**

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. **(separate only)**

Metals _____ and _____

Reason_____

_____

(2)

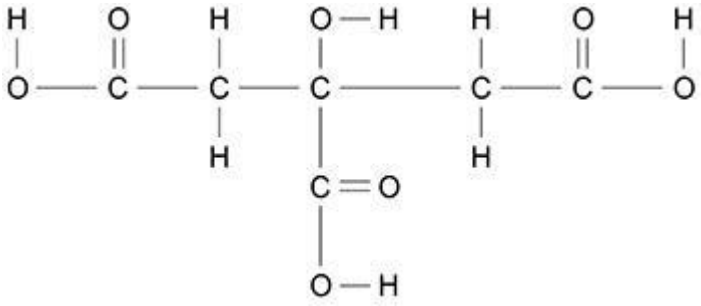
(Total 8 marks)

Q4.

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 ☐

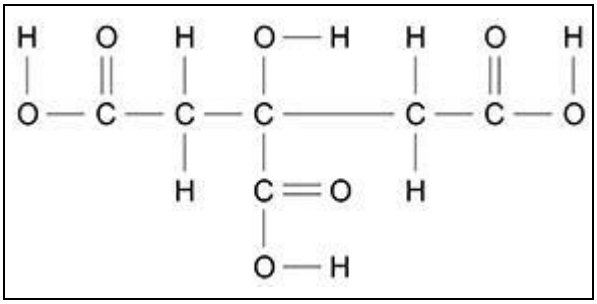
Metallic ☐

(1)

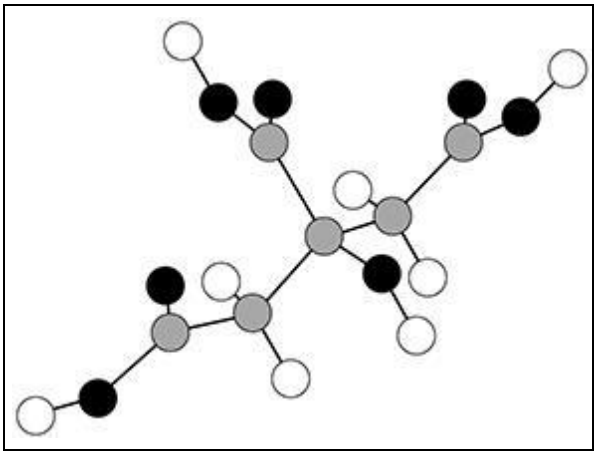
(c) **Figure 2** shows two representations of one molecule of citric acid, **A** and **B**.

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)

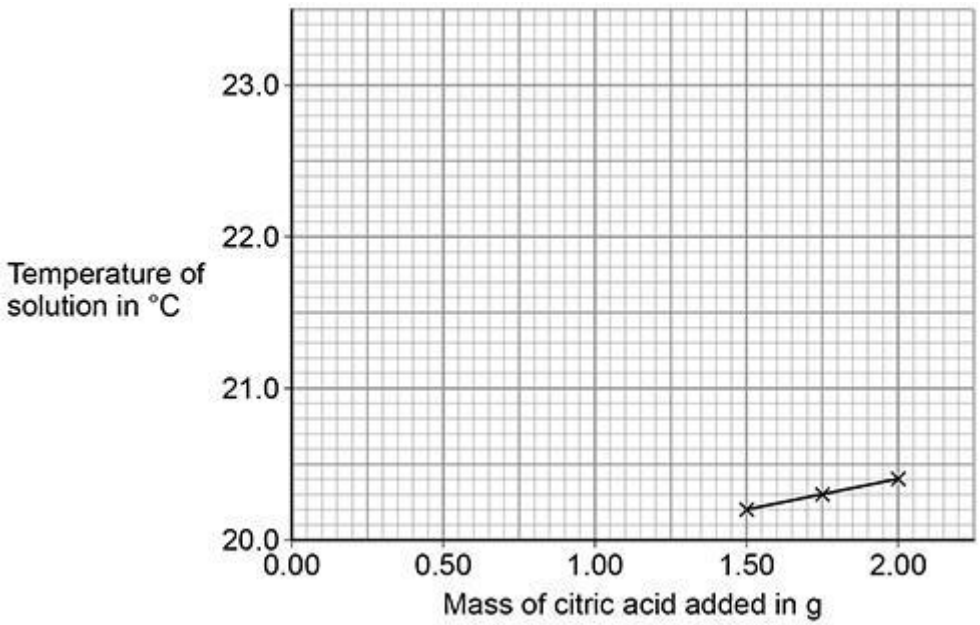
(e) Three of the student's results are plotted on the graph below.

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)

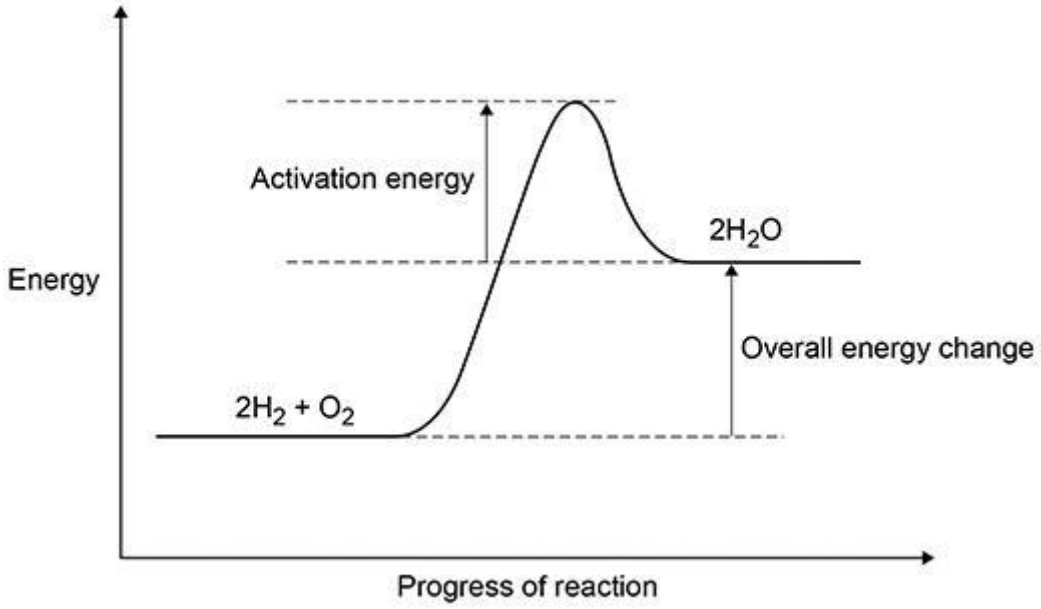
Q5.

The reaction between hydrogen and oxygen releases energy.

(a) A student drew a reaction profile for the reaction between hydrogen and oxygen.

Figure 1 shows the student's reaction profile.

Figure 1



The student made **two** errors when drawing the reaction profile.

Describe the **two** errors.

1 _____

_____

2 _____

_____

(2)

(b) The reaction between hydrogen and oxygen in a hydrogen fuel cell is used to produce electricity.

Hydrogen fuel cells and rechargeable cells are used to power some cars.

Give **two** advantages of using hydrogen fuel cells instead of using rechargeable cells to power cars. **(separate only)**

1 _____

_____

2 _____

_____

(2)

(c) Reactions occur at the positive electrode and at the negative electrode in a hydrogen fuel cell.

Write a half equation for **one** of these reactions. **(separate only)**

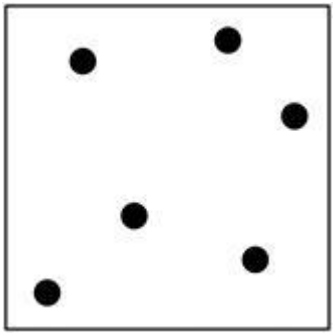
_____

(1)

(d) The three states of matter can be represented by a simple particle model.

Figure 2 shows a simple particle model for hydrogen gas.

Figure 2



Give **two** limitations of this simple particle model for hydrogen gas.

1 _____

_____

2 _____

_____

(2)

(e) The hydrogen gas needed to power a car for 400 km would occupy a large volume.

Suggest **one** way that this volume can be reduced.

_____

_____

(1)

(f) The energy needed for a car powered by a hydrogen fuel cell to travel 100 km is 58 megajoules (MJ).

The energy released when 1 mole of hydrogen gas reacts with oxygen is 290 kJ

The volume of 1 mole of a gas at room temperature and pressure is 24 dm^3

Calculate the volume of hydrogen gas at room temperature and pressure needed for the car to travel 100 km **(separate only)**

_____

_____

_____

_____

_____

_____

_____

_____

Volume of hydrogen gas = _____ dm^3

(4)

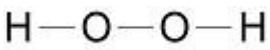
(Total 12 marks)

Q6.

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 ☐

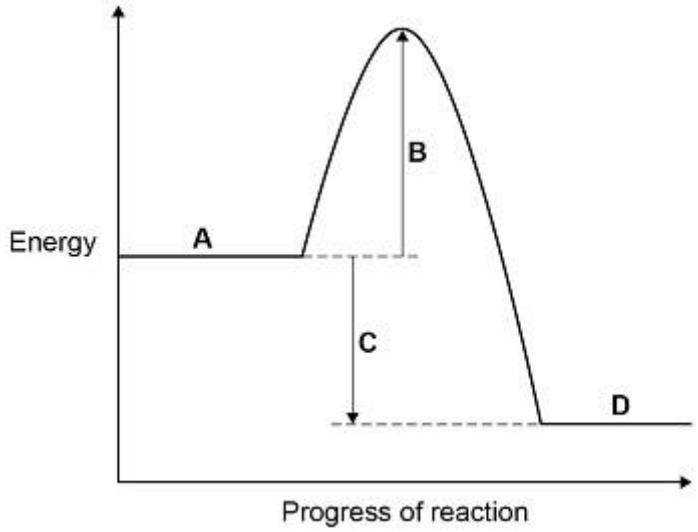
(1)

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.

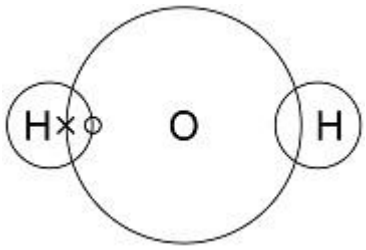
A hydrogen atom contains one electron.

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)

Q7.

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.

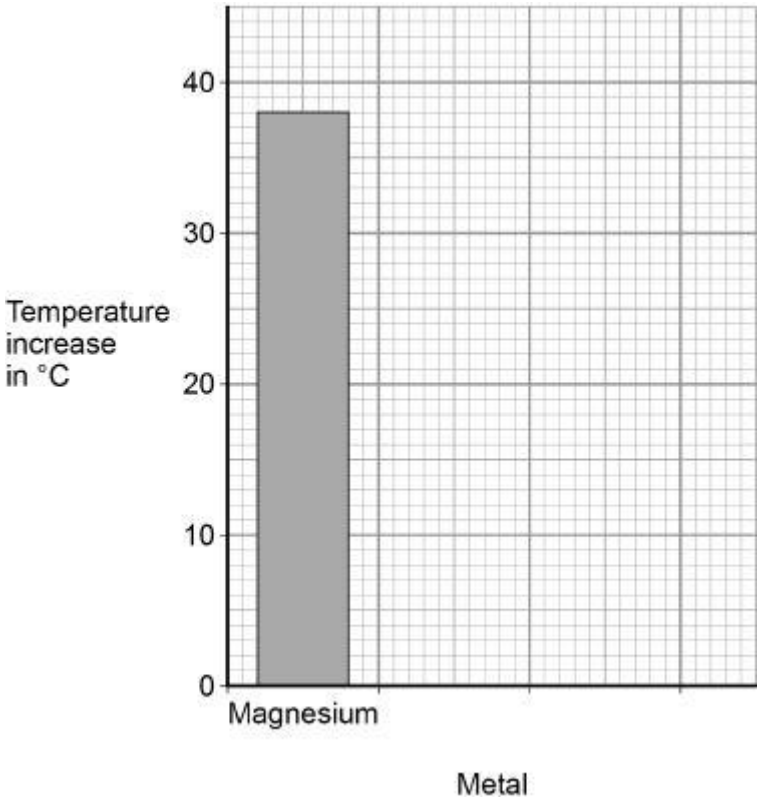
Metal	**Temperature increase in °C**
Magnesium	38
Nickel	8

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)**

_____

_____

_____

_____

_____

_____

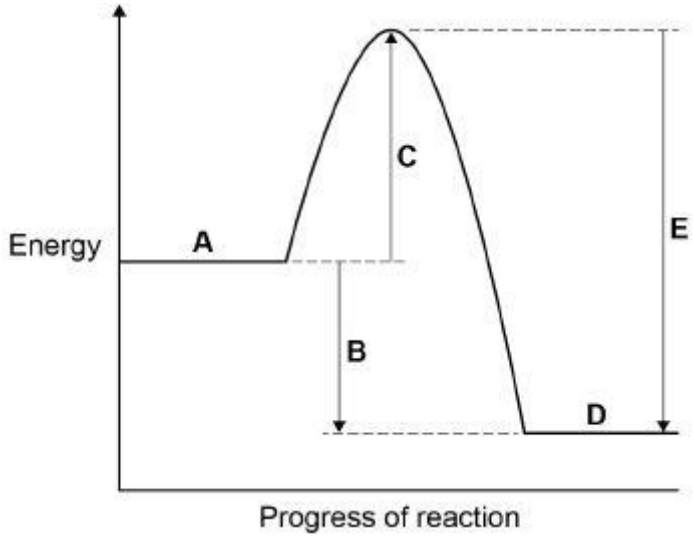
_____

_____

(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)

Q8.

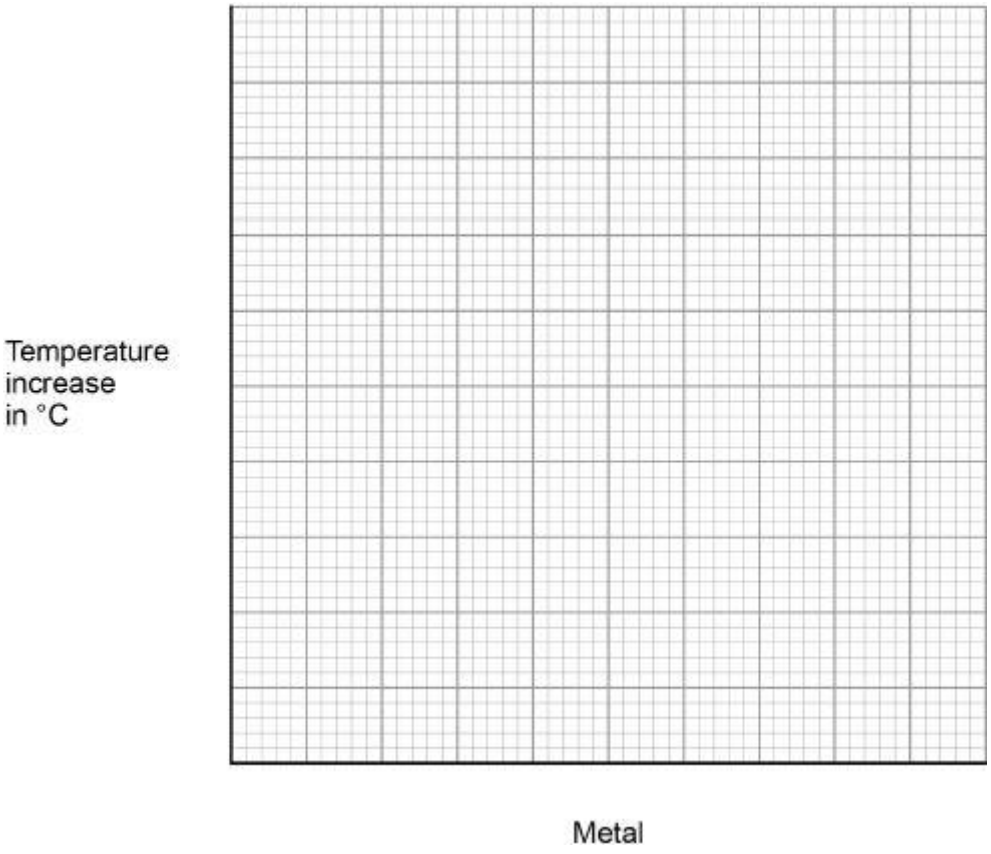
A student investigated the temperature change in displacement reactions between metals and copper sulfate solution.

The table below shows the student's results.

Metal	**Temperature increase in °C**
Copper	0
Iron	13
Magnesium	43
Zinc	17

(a) Plot the data from the table above on **Figure 1** as a bar chart.

Figure 1



(2)

(b) 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)

(c) The temperature change depends on the reactivity of the metal.

The student's results are used to place copper, iron, magnesium and zinc in order of their reactivity.

Describe a method to find the position of an unknown metal in this reactivity series.

Your method should give valid results.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(d) Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 2**.

Figure 2

(3)

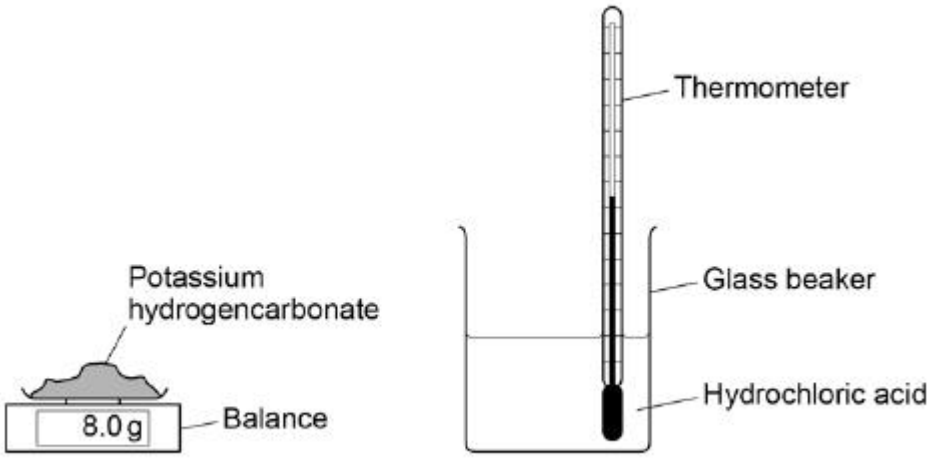
(Total 10 marks)

Q9.

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 cm^3 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 cm^3 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	☐
Same balance	☐
Same thermometer	☐
Starting temperature of hydrochloric acid	☐
Volume of hydrochloric acid	☐

(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)

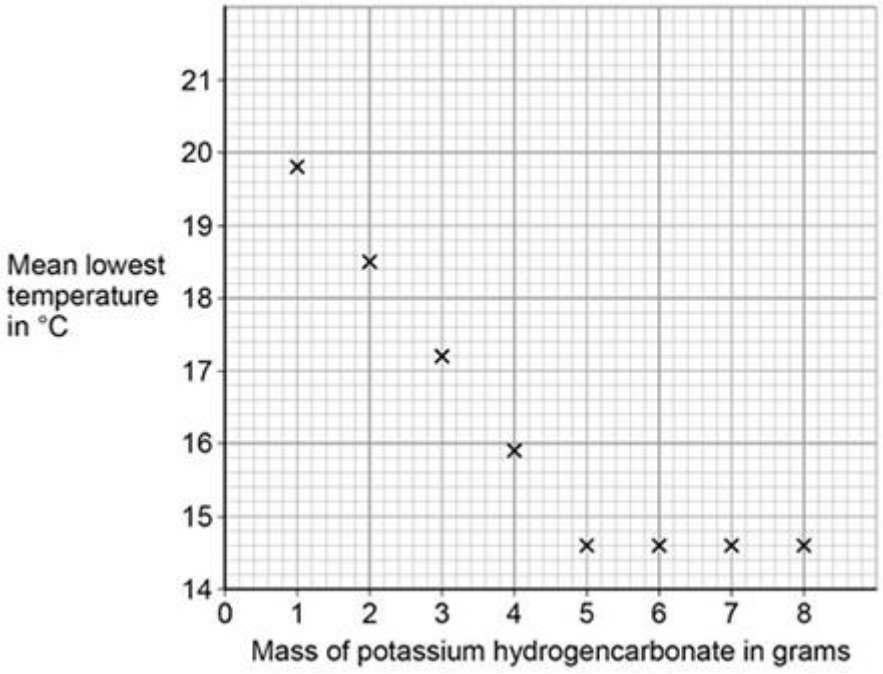
(g) How do the results show that the reaction is endothermic?

_____

_____

(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)

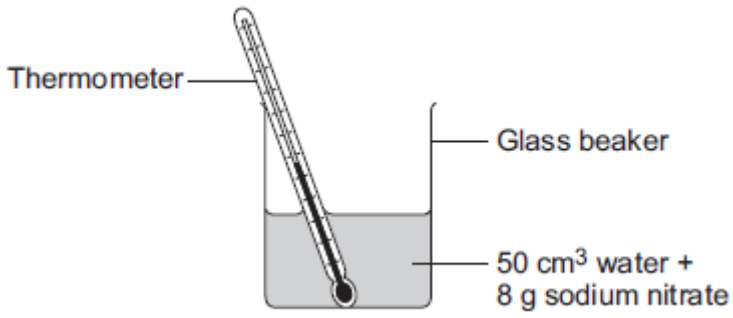
(Total 15 marks)

Q10.

This question is about temperature changes.

(a) A student investigated the temperature change when 8 g of sodium nitrate dissolves in 50 cm^3 of water.

The diagram below shows the apparatus the student used.



The student did the experiment five times.
Table 1 shows the results.

Table 1

Experiment	Decrease in temperature of water in °C
1	5.9
2	5.7
3	7.2
4	5.6

5	5.8

(i) Calculate the mean decrease in temperature.
Do not use the anomalous result in your calculation.

_____

_____

Mean decrease in temperature = _____ °C

(2)

(ii) Suggest **one** change in the apparatus in the diagram above which would improve the accuracy of the results.
Give a reason for your answer.

_____

_____

_____

_____

(2)

(b) The student investigated the temperature change when different masses of sodium carbonate were added to 50 cm^3 of water at 20 °C.

Table 2 below shows the results.

Table 2

Mass of sodium carbonate in g	**Final temperature of solution in °C**
2.0	21.5
4.0	23.0
6.0	24.5
8.0	26.0
10.0	26.6
12.0	26.6
14.0	26.6

Describe the relationship between the mass of sodium carbonate added and the final temperature of the solution.

Use values from **Table 2** in your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q11.

This question is about energy changes in chemical reactions.

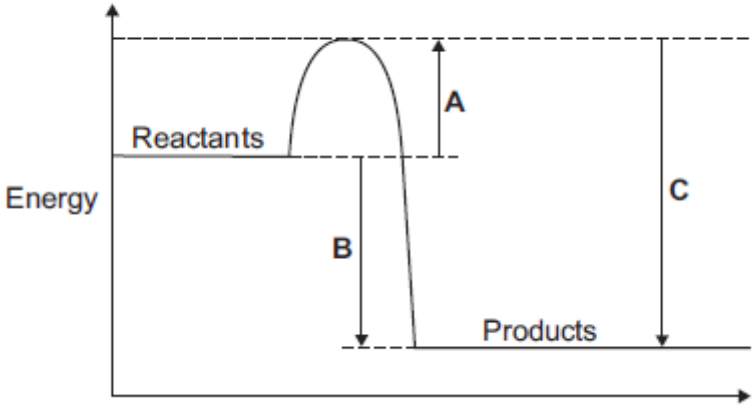
(a) Complete the word equation for the combustion of hydrogen.

hydrogen + oxygen ⟶ _____

(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

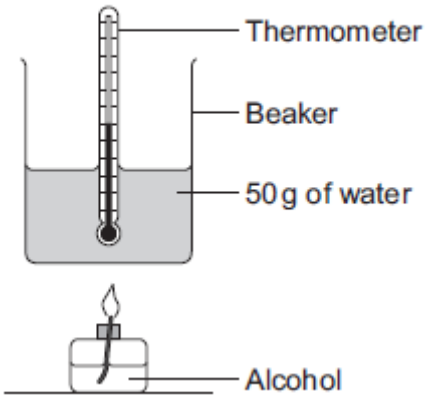
(1)

(c) Alcohols are used as fuels.

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

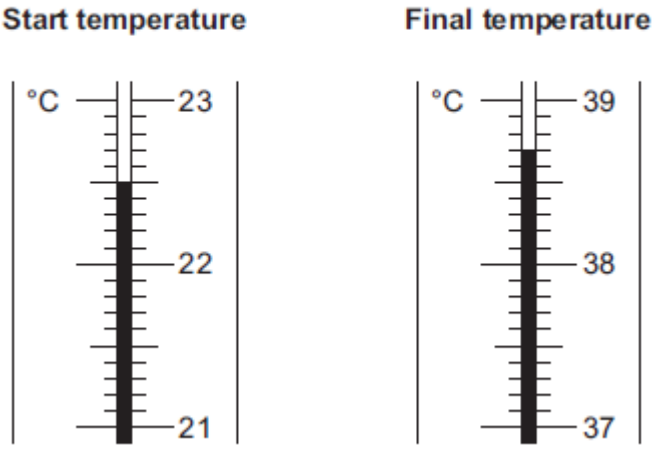
The students used the apparatus shown in **Figure 2**.

Figure 2



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

Figure 3



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:

Heat energy released = m × 4.2 × increase in temperature

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

m = _____ 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)

(v) The value in a data book for the amount of heat energy released when 1 g of butanol is burned completely is 36.2 kJ.

Suggest two reasons why the students' result for butanol is lower than the data book value.

1. _____

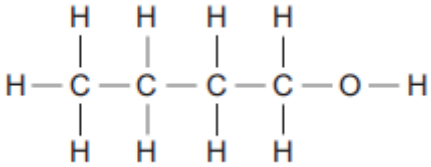
_____

2. _____

_____

(2)

(vi) The displayed structure of butanol is:



What is the functional group of the alcohol?

Tick (✓) **one** box. **(separate only)**

— C — C ☐

— C — H ☐

— O — H ☐

(1)

(Total 14 marks)