

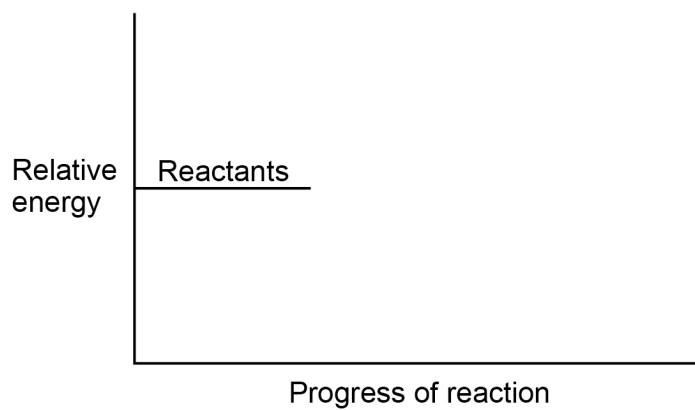
1.1

The reaction between sodium and chlorine is an exothermic reaction.

Complete the reaction profile for the reaction between sodium and chlorine.

[2 marks]

Figure 3



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

Table 2 shows the student's results.

Table 2

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

2.1

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 mark]

2.2

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.

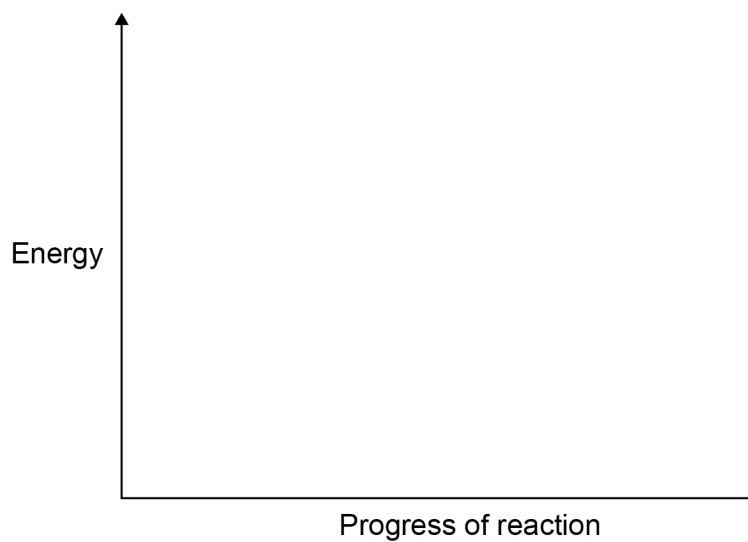
[4 marks]

2.3

Draw a fully labelled reaction profile for the reaction between zinc and copper sulfate solution on **Figure 5**.

[3 marks]

Figure 5



3.1

Bromine reacts with methane in sunlight.

Figure 9 shows the displayed formulae for the reaction of bromine with methane.

Figure 9

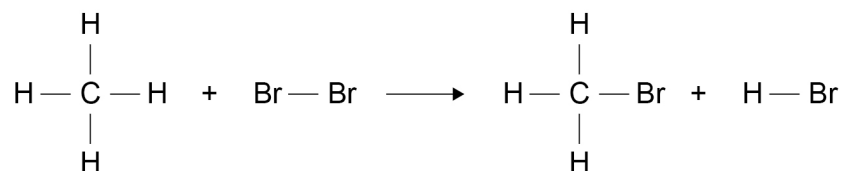


Table 3 shows the bond energies and the overall energy change in the reaction.

Table 3

	C—H	Br—Br	C—Br	H—Br	Overall energy change
Energy in kJ/mol	412	193	X	366	– 51

Calculate the bond energy **X** for the C—Br bond.

Use **Figure 9** and **Table 3**.

[4 marks]

Bond energy **X** = _____ kJ/mol

You do **not** need to write about safety precautions.

[6 marks]

[illegible]

5.1

Hydrogen reacts with oxygen.

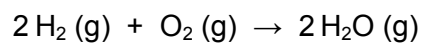
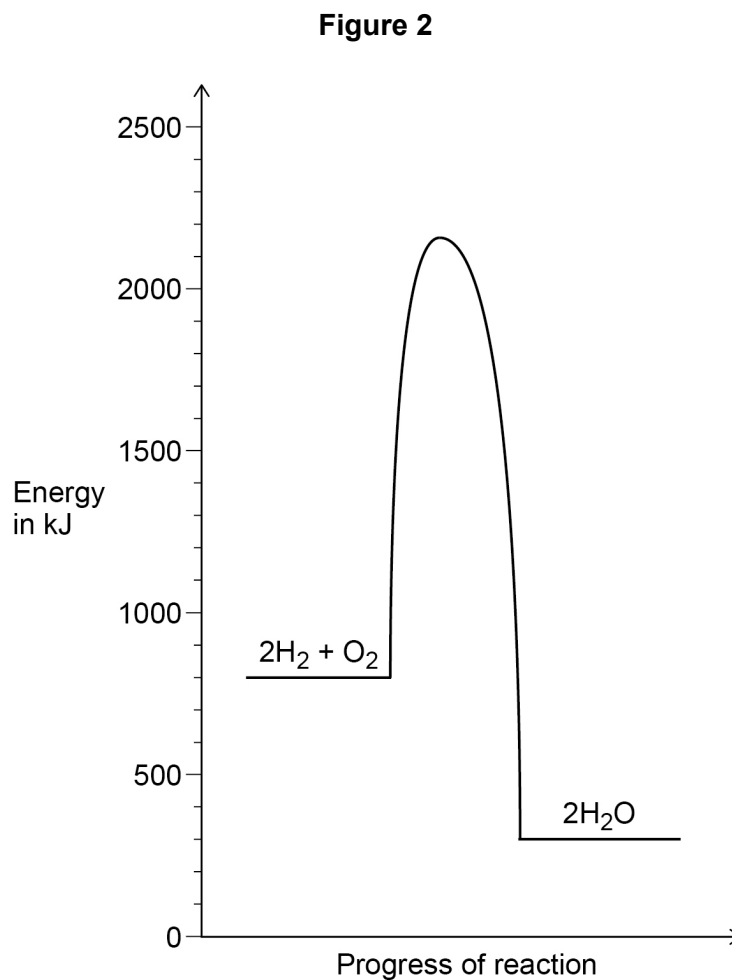


Figure 2 shows the relative energies of the reactants and products at a certain temperature.



Label the activation energy on **Figure 2**.

[1 mark]

5.2

Determine the overall energy change for the reaction between hydrogen and oxygen shown in Question 5.1

Use **Figure 2**.

[2 marks]

Energy change = _____ kJ

5.3

The equation shows the decomposition of hydrogen peroxide.

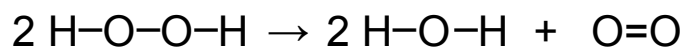


Table 1 shows the bond energies.

Table 1

Bond	O–O	O=O	O–H
Bond dissociation energy in kJ per mole	138	496	463

Calculate the overall energy change for the reaction.

[3 marks]

Energy change = _____ kJ

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

Figure 7 shows the displayed formula equation for the reaction.

Figure 7

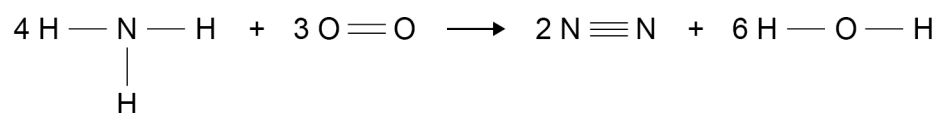


Table 3 shows some bond energies.

Table 3

Bond	N — H	O = O	N ≡ N	O — H
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6.1

Calculate the overall energy change for the reaction.

Use **Figure 7** and **Table 3**.

[3 marks]

Overall energy change = _____ kJ

6.2

Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in Question 6.1

[2 marks]

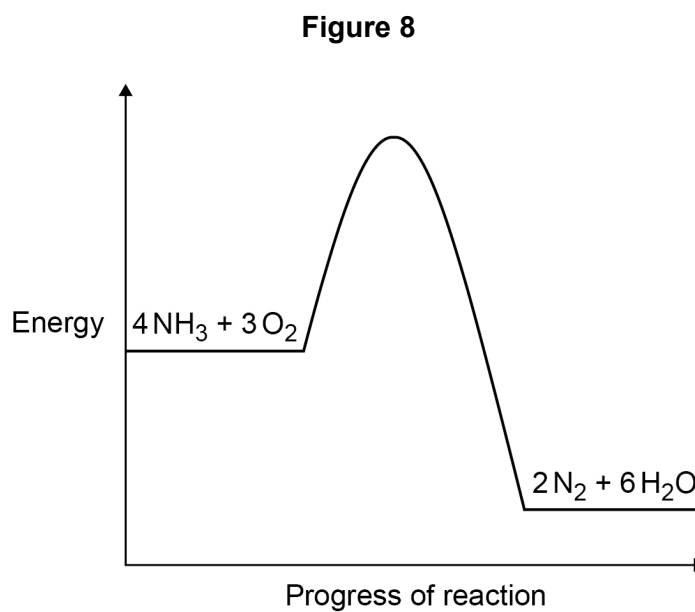
6.3

Figure 8 shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 8** by labelling the:

- activation energy
- overall energy change.

[2 marks]



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.

7.1

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

[2 marks]

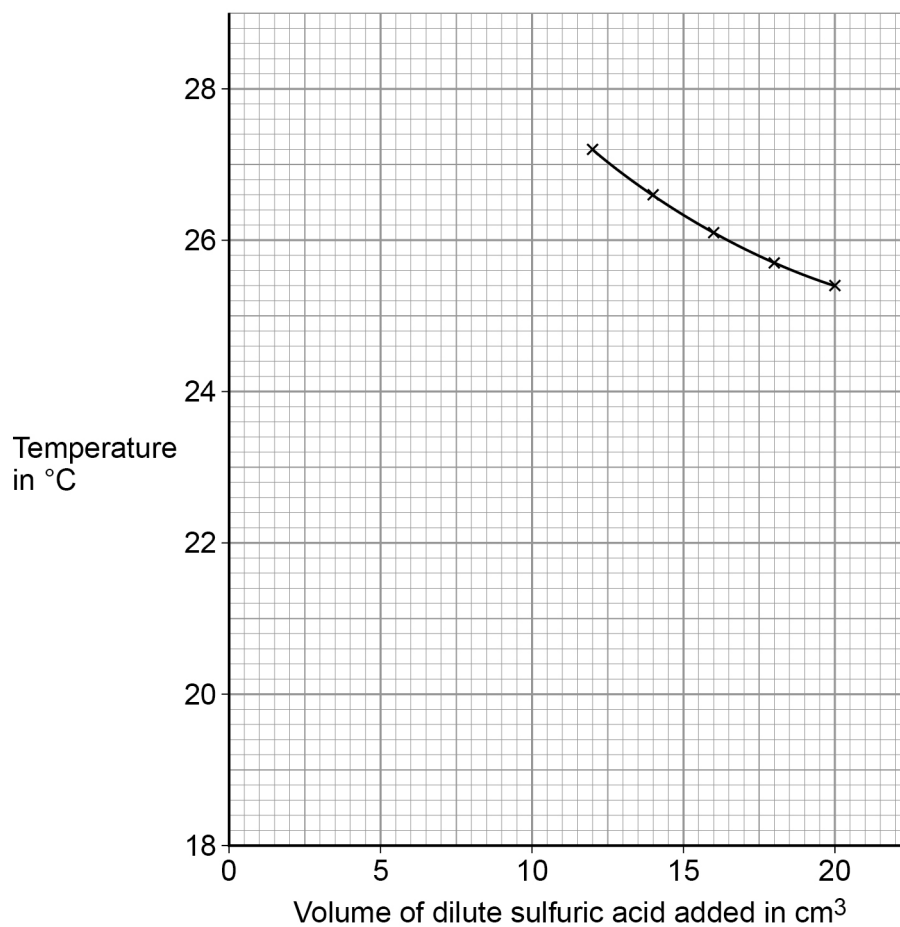
Table 6 shows some of the student's results.

Table 6

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

Figure 11 shows some of the data from the investigation.

Figure 11



7.2

Complete **Figure 11**:

- plot the data from **Table 6**
- draw a line of best fit through these points
- extend the lines of best fit until they cross.

[4 marks]

7.3

Determine the overall temperature change when the reaction is complete.

Use **Figure 11**.

[1 mark]

Overall temperature change = _____ °C

A student investigated the temperature change when magnesium was added to copper sulfate solution.

This is the method used.

1. Pour 30 cm³ of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of copper sulfate solution every minute for 3 minutes.
3. Add magnesium on the fourth minute.
4. Measure the temperature of the mixture at 5 minutes and then every minute up to 14 minutes.

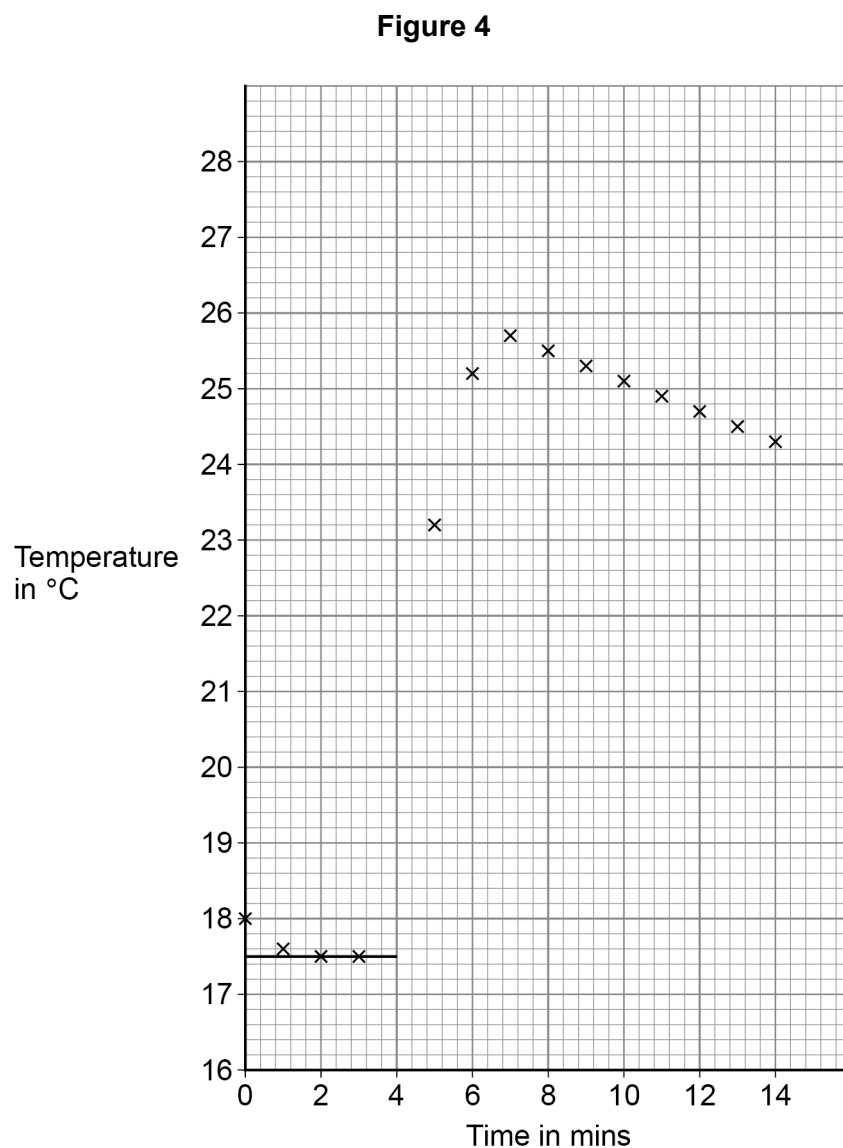
8.1

Suggest why the copper sulfate solution was left for four minutes before adding the magnesium.

[1 mark]

The student used the results to plot a graph.

Figure 4 shows the graph.



8.2

Complete **Figure 4** by:

- drawing a line of best fit through all the points after 7 minutes
- extending the line back to 4 minutes.

[2 marks]

8.3

The temperature change for the reaction is the temperature difference between the two graph lines at 4 minutes.

Determine the temperature change for the reaction.

Use **Figure 4**.

[2 marks]

Temperature change = _____ °C

8.4

Explain why the temperature of the mixture decreases after 7 minutes.

[2 marks]

8.5

The student repeated the experiment with an unknown metal **Q** instead of magnesium.

All the other variables were kept the same.

The student recorded a smaller temperature change.

Suggest the identity of metal **Q**.

Give **one** reason for your answer.

[2 marks]

Metal **Q** _____

Reason _____

9.1

The displacement reaction between aluminium and iron oxide has a high activation energy.

What is meant by 'activation energy'?

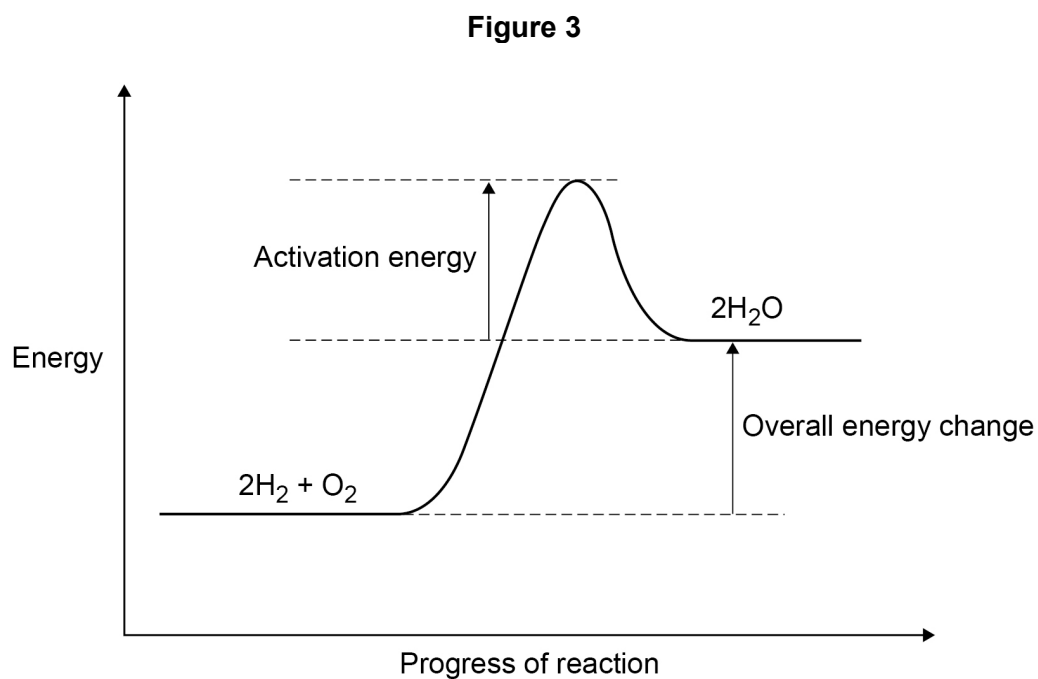
[1 mark]

The reaction between hydrogen and oxygen releases energy.

10.1

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

Figure 3 shows the student's reaction profile.



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

Describe the **two** errors.

[2 marks]

1 _____

2 _____

This question is about citric acid ($\text{C}_6\text{H}_8\text{O}_7$).

Citric acid is a solid.

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

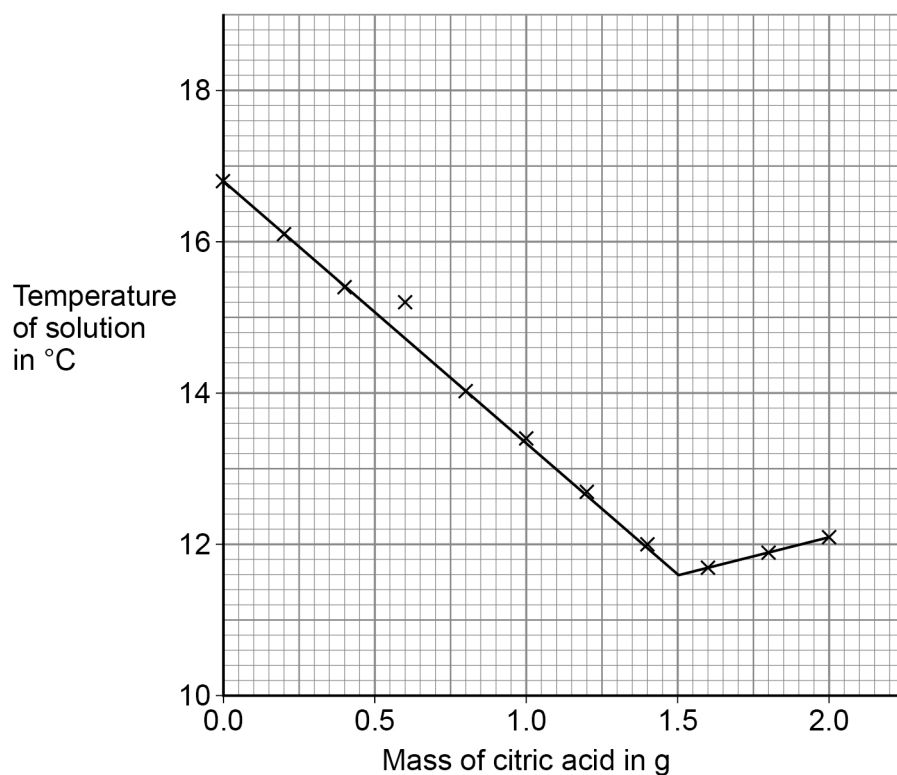
This is the method used.

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.

Figure 6 shows the student's graph.

Figure 6



11.1

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

You should use data from **Figure 6** in your answer.

[3 marks]

11.2

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 **Figure 6** 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 marks]

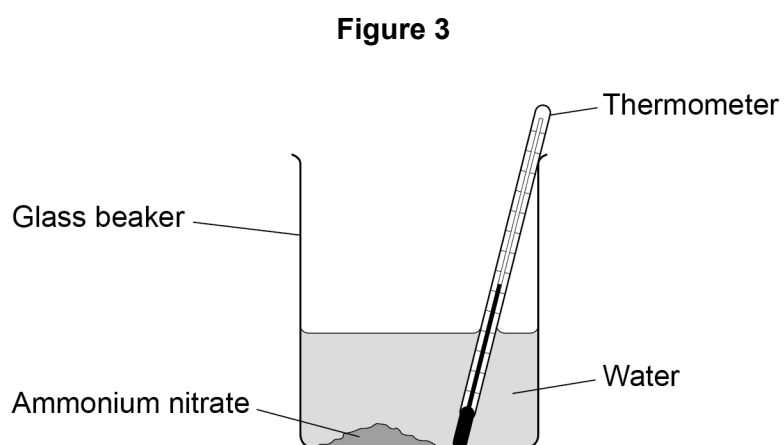
This question is about energy change.

A student investigated the temperature change when 10 g of ammonium nitrate was added to 100 cm³ of water.

This is the method used.

1. Measure the temperature of 100 cm³ of water.
2. Add 10 g of ammonium nitrate.
3. Stir once.
4. Measure the temperature of the solution every minute for 7 minutes.

Figure 3 shows the apparatus.



12.1

Give **three** improvements to the investigation to make the results more accurate.

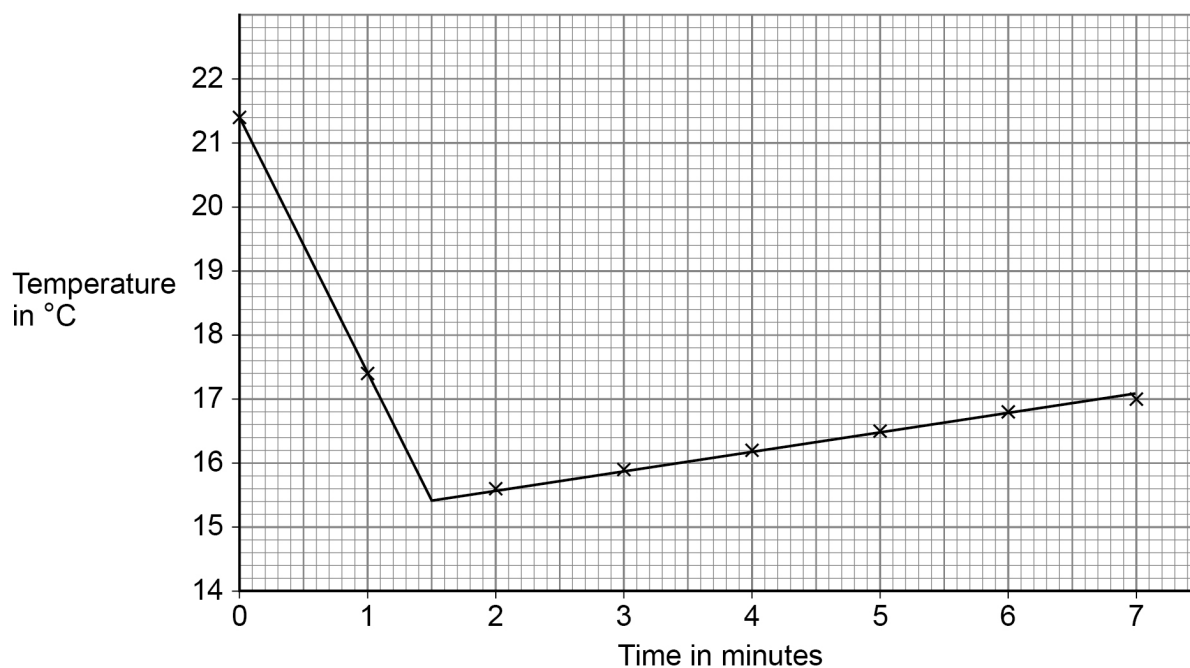
[3 marks]

1 _____

2 _____

3 _____

12.2

Figure 4 shows the results.**Figure 4**

Explain the results.

[4 marks]

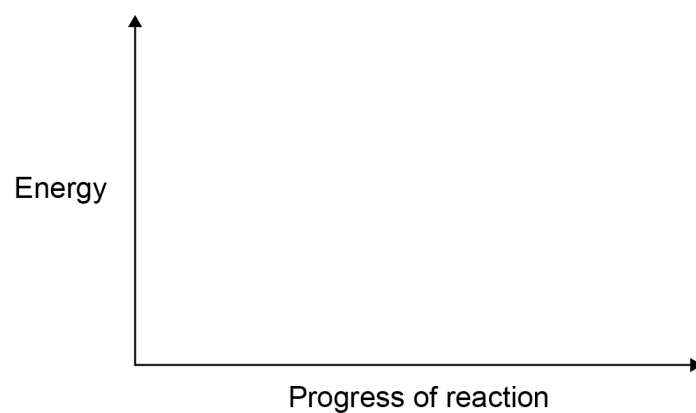
12.3

Draw a reaction profile for an exothermic reaction.

You should label:

- the energy level of the reactants and of the products
- the activation energy
- the overall energy change.

[4 marks]



Methane, ethane, propane and butane all react with oxygen to produce carbon dioxide and water.

13.1

Suggest why a mixture of methane and oxygen does **not** react at room temperature.

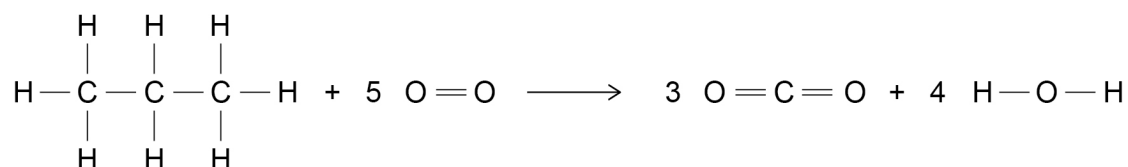
Answer in terms of particles.

[2 marks]

13.2

Propane reacts with oxygen to produce carbon dioxide and water.

The displayed formula equation for the reaction is:



The reaction is exothermic.

In the reaction, the energy released when forming new bonds is 1640 kJ/mol greater than the energy needed when breaking bonds.

Table 4 shows bond energies.

Table 4

Bond	H—C	C—C	O=O	C=O	O—H
Bond energy in kJ/mol	410	X	500	740	460

Calculate the C—C bond energy (X).

[5 marks]

X = _____ kJ/mol

14.1

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 marks]

This question is about the reaction between hydrogen sulfide (H₂S) and oxygen.

The equation for the reaction is:



15.1

Figure 6 shows part of the reaction profile for the reaction.

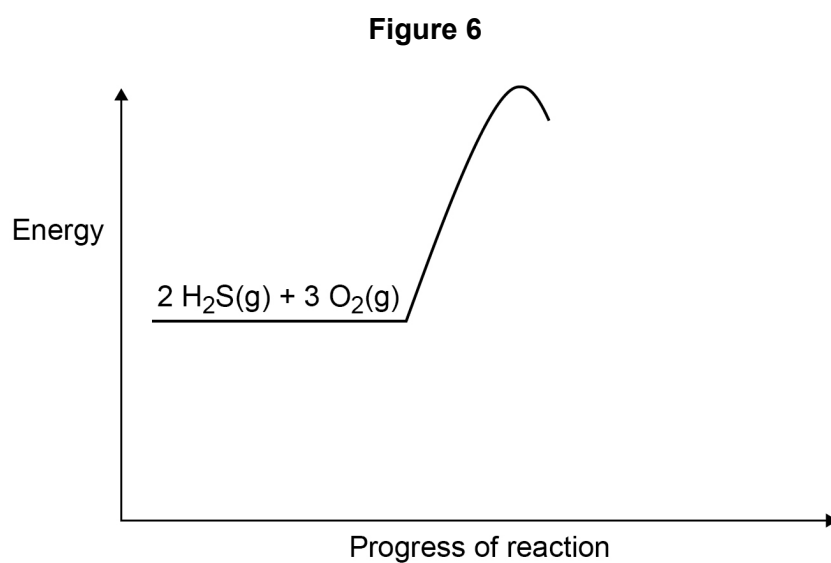
The reaction is exothermic.

Complete **Figure 6**.

You should:

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

[3 marks]



15.2

Figure 7 shows the displayed formula equation for the reaction of hydrogen sulfide with oxygen.

Figure 7

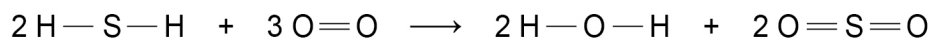


Table 5 shows some of the bond energies.

Table 5

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 S=O bond.

Use **Figure 7** and **Table 5**.

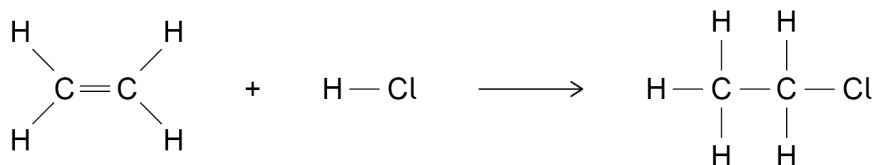
[5 marks]

X = _____ kJ/mol

16.1

Ethene and hydrogen chloride react to produce chloroethane.

The displayed formulae equation for the reaction is:



The reaction is exothermic.

In the reaction the energy released forming new bonds is 56 kJ/mol greater than the energy needed to break existing bonds.

Table 1 shows some bond energies.

Table 1

Bond	H–C	C=C	H–Cl	C–C	C–Cl
Bond energy in kJ/mol	413	X	431	346	339

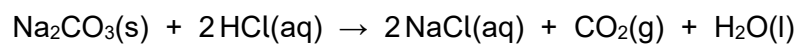
Calculate the bond energy **X**.

[4 marks]

X = _____ kJ/mol

Sodium carbonate reacts with hydrochloric acid in an exothermic reaction.

The equation for the reaction is:



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

[6 marks]

[illegible]

17.2

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

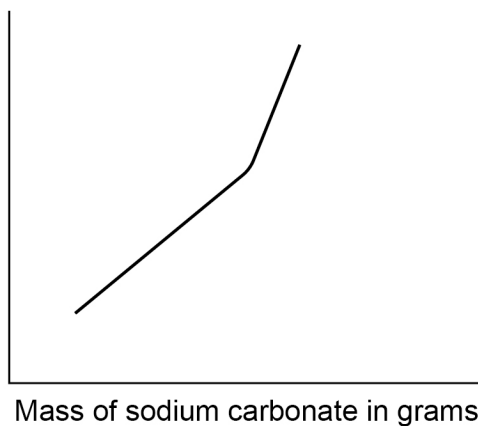
Which sketch graph shows the results obtained when sodium carbonate was added until in excess?

[1 mark]

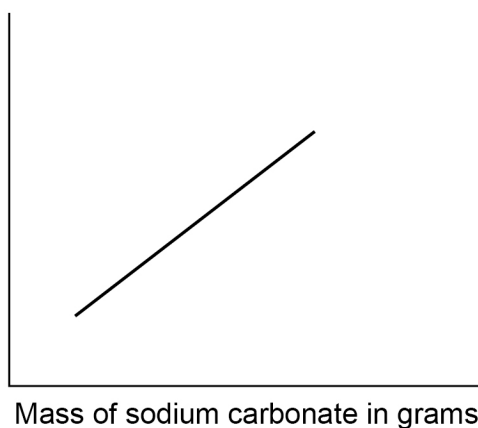
Tick (✓) **one** box.

A

Highest temperature reached by the reaction mixture in °C

☐**B**

Highest temperature reached by the reaction mixture in °C

☐**C**

Highest temperature reached by the reaction mixture in °C

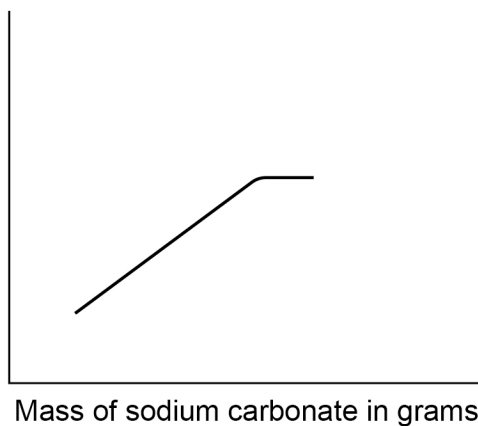
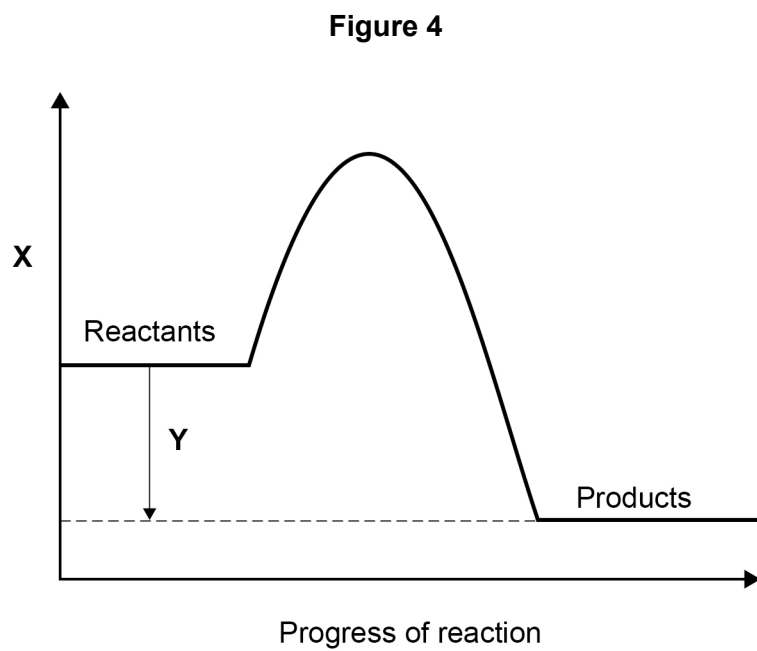
☐

Figure 4 shows a reaction profile for the reaction of sodium carbonate with hydrochloric acid.



17.3

What do labels **X** and **Y** represent on **Figure 4**?

[2 marks]

X _____

Y _____

17.4

How does the reaction profile show that the reaction is exothermic?

Use **Figure 4**.

[1 mark]

Energy is taken in from the surroundings when hydrated cobalt chloride is heated.

18.1

What type of reaction takes place when hydrated cobalt chloride is heated?

[1 mark]

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 cm³ 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.

Table 2 shows the results.

Table 2

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

19.1

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

[1 mark]

This question is about hydrogen and compounds of hydrogen.

Figure 3 shows the displayed formulae for the reaction between hydrogen and chlorine.

Figure 3

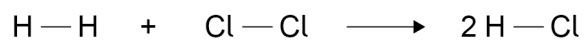


Table 4 shows the bond energies.

Table 4

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

20.1

Which expression shows how to calculate the overall energy change for the reaction in **Figure 3**?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

$436 + 346 + 432 \text{ kJ/mol}$

☐

$436 + 346 + (2 \times 432) \text{ kJ/mol}$

☐

$436 + 346 - 432 \text{ kJ/mol}$

☐

$436 + 346 - (2 \times 432) \text{ kJ/mol}$

☐

The reaction between hydrogen and chlorine is exothermic.

20.2

Explain why this reaction releases energy to the surroundings.

[2 marks]

20.3

Figure 4 shows part of a reaction profile for the reaction between hydrogen and chlorine.

Complete the reaction profile in **Figure 4**.

You should:

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

[3 marks]

Figure 4

