Q1.

RP4 - Sodium carbonate reacts with hydrochloric acid in an exothermic reaction.

The equation for the reaction is:

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

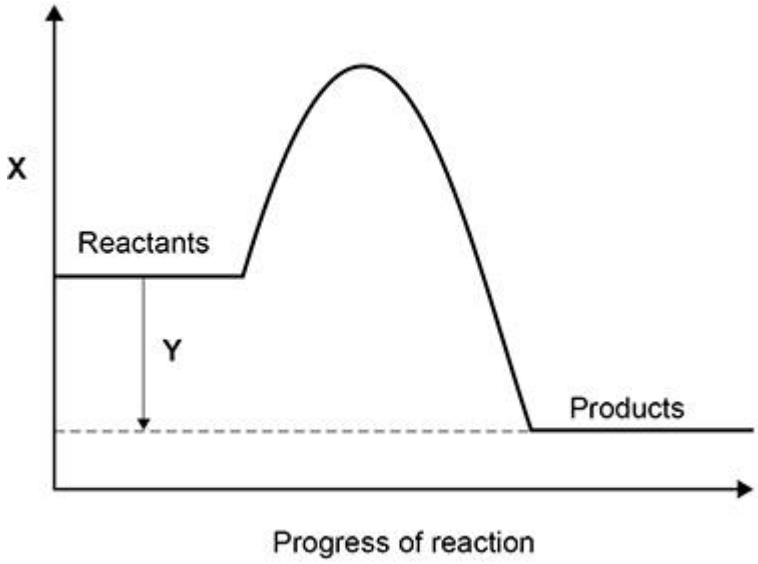
A student investigated the effect of changing the mass of sodium carbonate powder on the highest temperature reached by the reaction mixture.

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

(6)

Figure 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)

Q2.

MATHS - 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)

(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.

_____

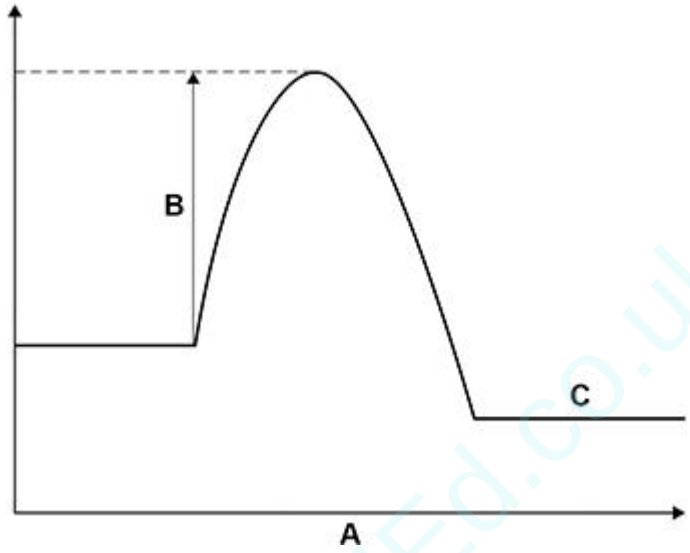
_____

_____

_____

(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)

Q3.

This question is about chemical reactions and energy.

Hydrogen reacts with oxygen to produce water.

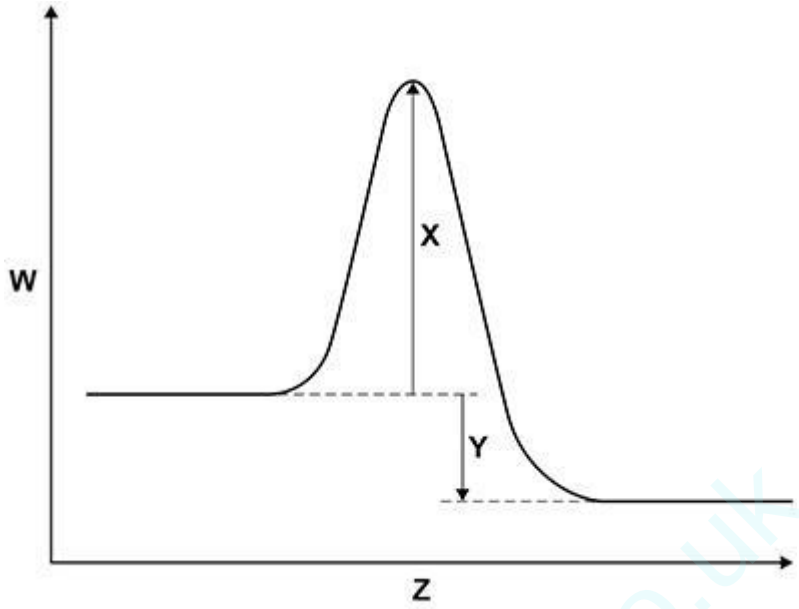
This reaction releases energy.

(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)

Q4.

RP4 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.

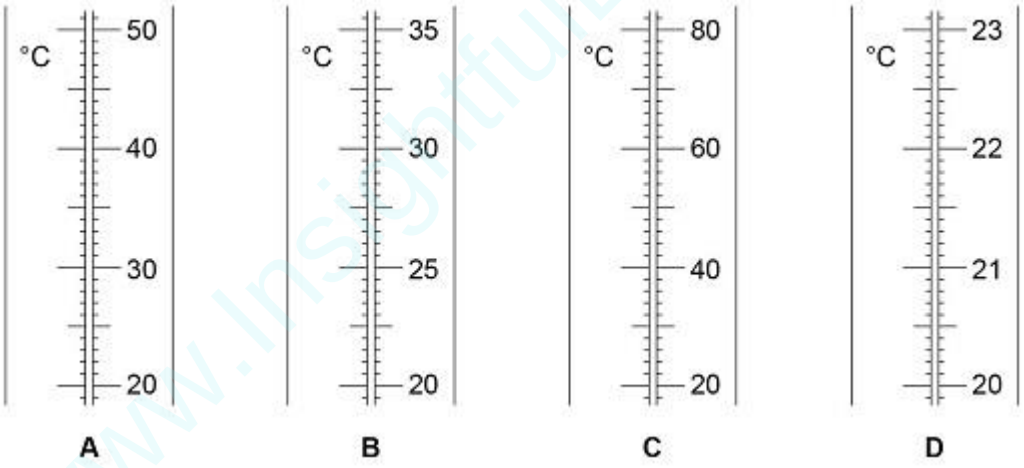
3. Stir the solution.

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.

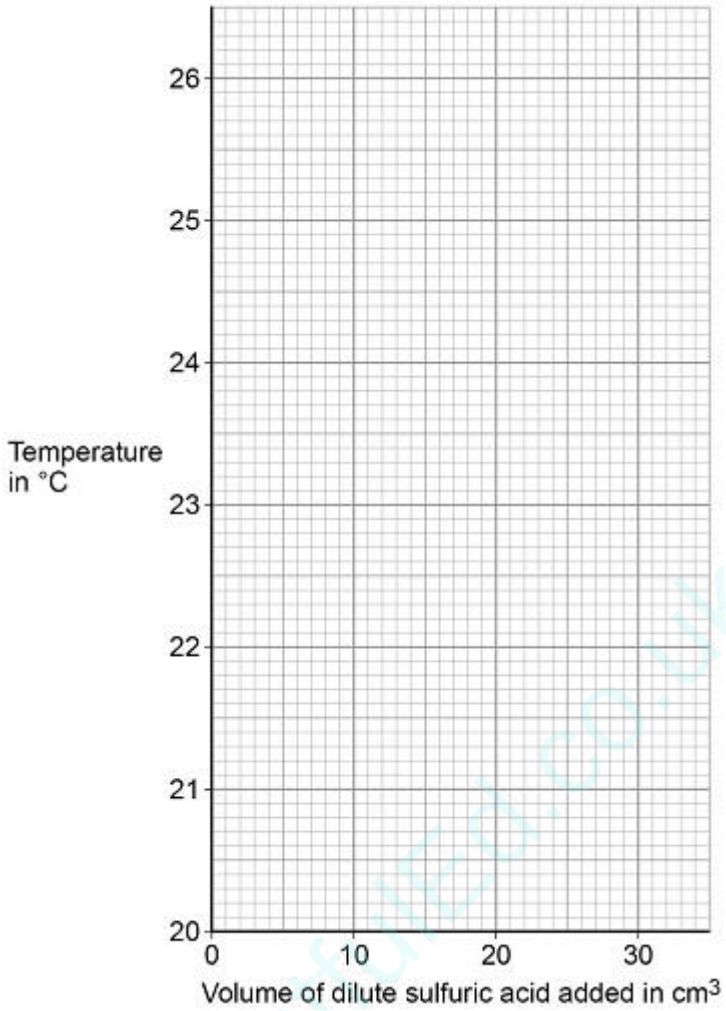
Volume of dilute sulfuric acid added in cm^3	Temperature in °C
5	21.2
10	22.0
15	22.8
20	23.6
25	24.4
30	25.2

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)

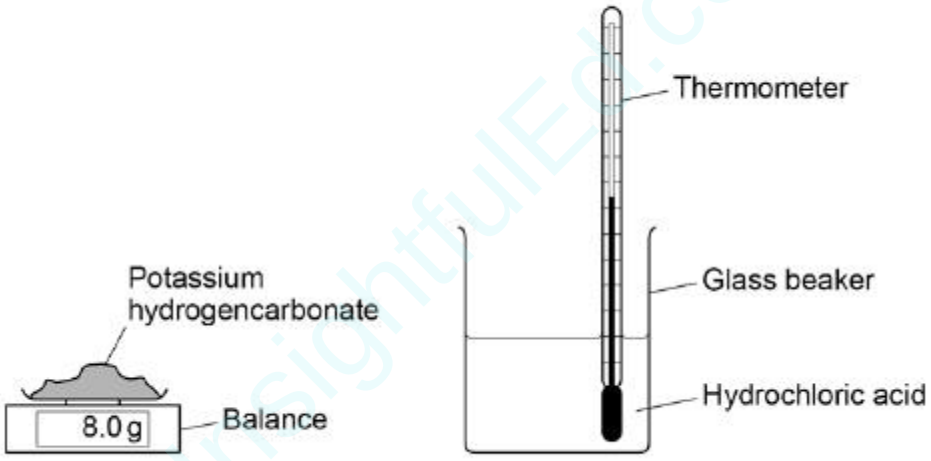
(Total 11 marks)

Q5.

RP4 - 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)

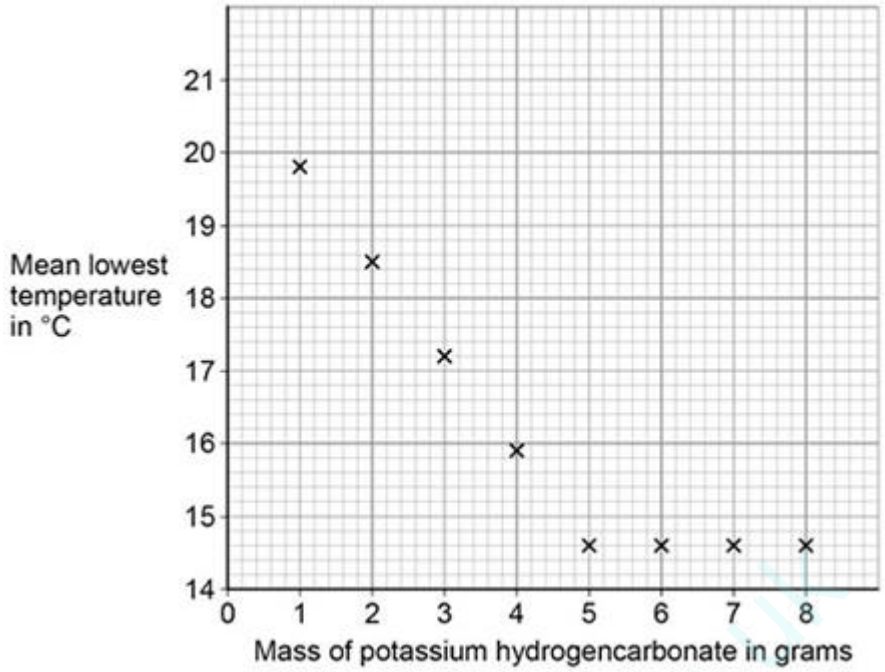
(g) How do the results show that the reaction is endothermic?

_____

_____

(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)

Q6.

This question is about citric acid.

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)

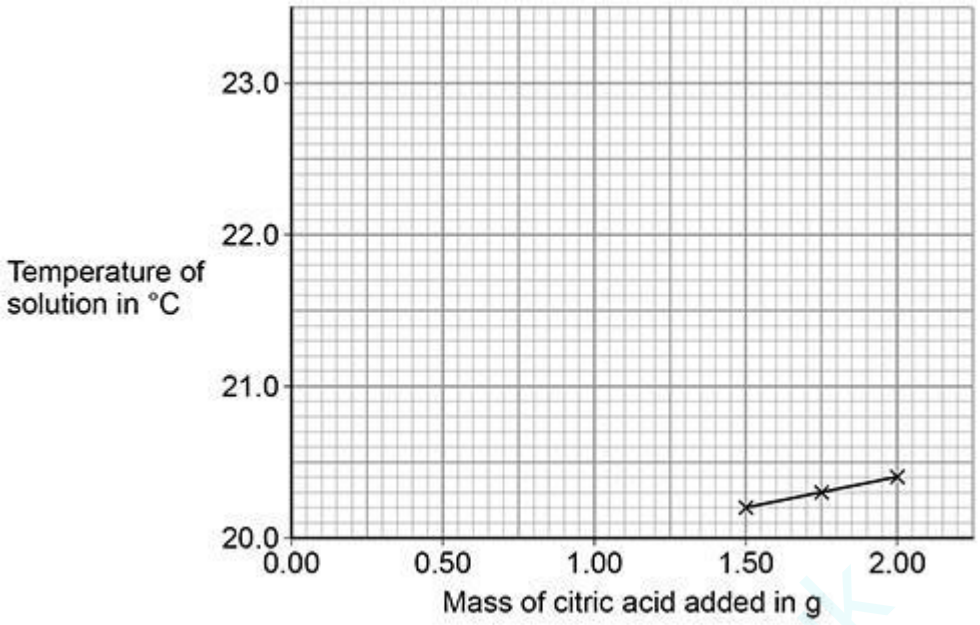
(e) Three of the student's results are plotted on the graph below.

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)

Q7.

This question is about compounds of oxygen and hydrogen.

Figure 1 represents the structure of hydrogen peroxide.

Figure 1

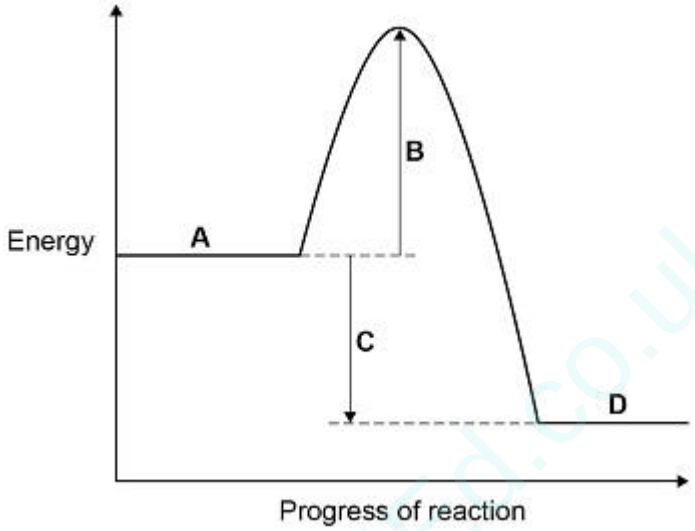
H—O—O—H

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 ☐

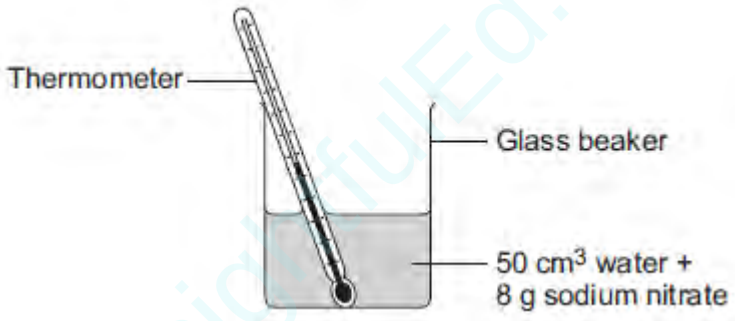
(1)

Q8.

RP4 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)

Q9.

This question is about energy changes in chemical reactions.

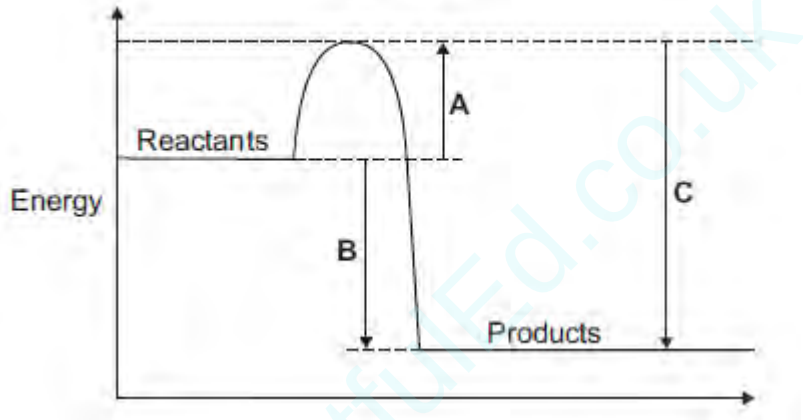
(a) Complete the word equation for the combustion of hydrogen.

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)

Q10.

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

Citric acid is a solid.

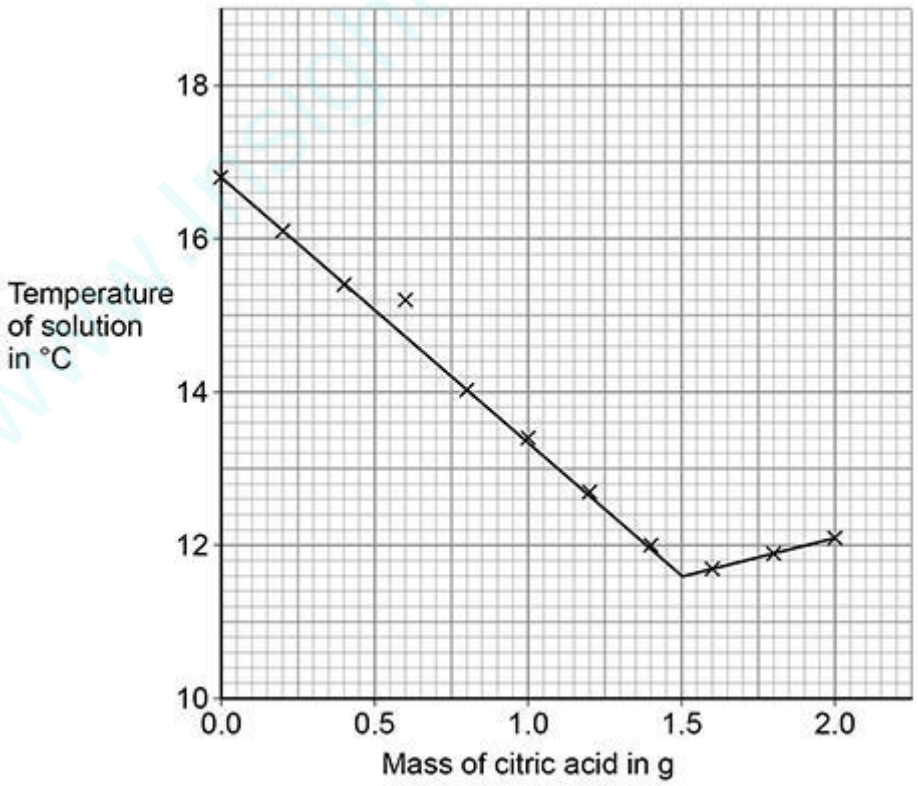
A student investigated the temperature change during the reaction between citric acid and sodium hydrogencarbonate solution.

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)

Q11.

Instant cold packs are used to treat sports injuries.

One type of cold pack has a plastic bag containing water. Inside this bag is a smaller bag containing ammonium nitrate.

The outer bag is squeezed so that the inner bag bursts. The pack is shaken and quickly gets very cold as the ammonium nitrate dissolves in the water.

(a) **One** of the statements in the table is correct.

Put a tick (✓) next to the correct statement.

Statement	(✓)
The bag gets cold because heat energy is given out to the surroundings.	
The bag gets cold because heat energy is taken in from the surroundings.	
The bag gets cold because plastic is a good insulator.	

(1)

(b) Draw a ring around the word that best describes the change when ammonium nitrate dissolves in water.

electrolysis **endothermic** **exothermic**

(1)

(c) Suggest and explain why the pack is shaken after the inner bag has burst.

_____

_____

(2)

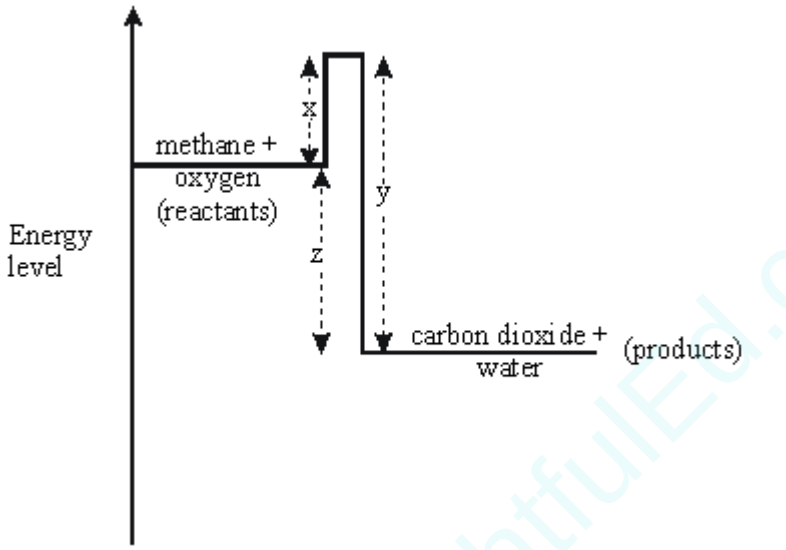
(Total 4 marks)

Q12.

The symbol equation below shows the reaction when methane burns in oxygen.

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

An energy level diagram for this reaction is shown below.



(a) Which chemical bonds are broken and which are formed during this reaction?

(4)

(b) Explain the significance of x, y and z on the energy level diagram in terms of the energy transfers which occur when these chemical bonds are broken and formed.

(5)

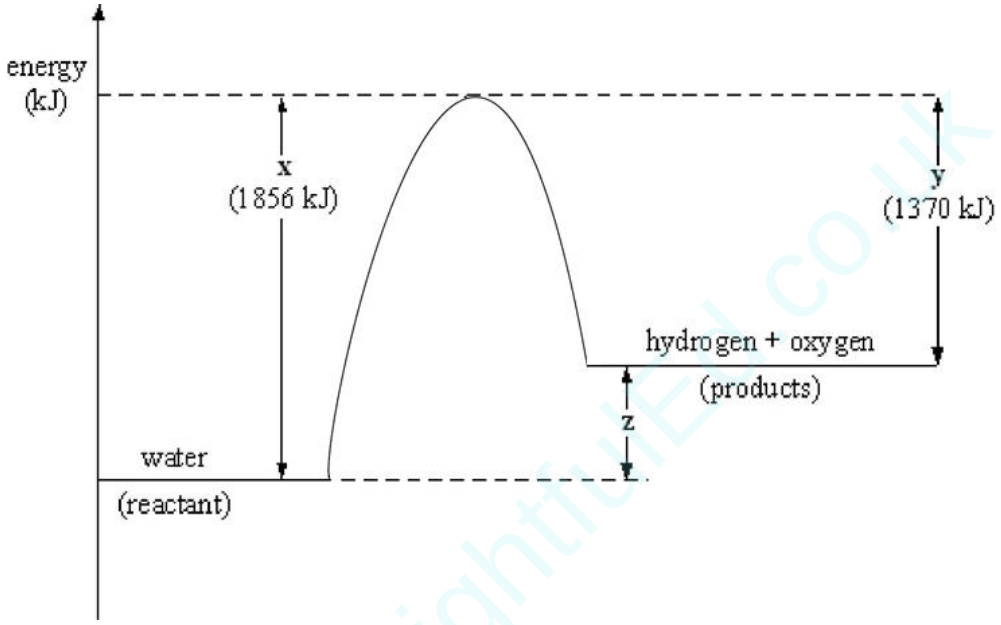
(Total 9 marks)

Q13.

The symbol equation shows the decomposition of water.

$2H_2O \rightarrow 2H_2 + O_2$

An energy level diagram for this reaction is shown below.

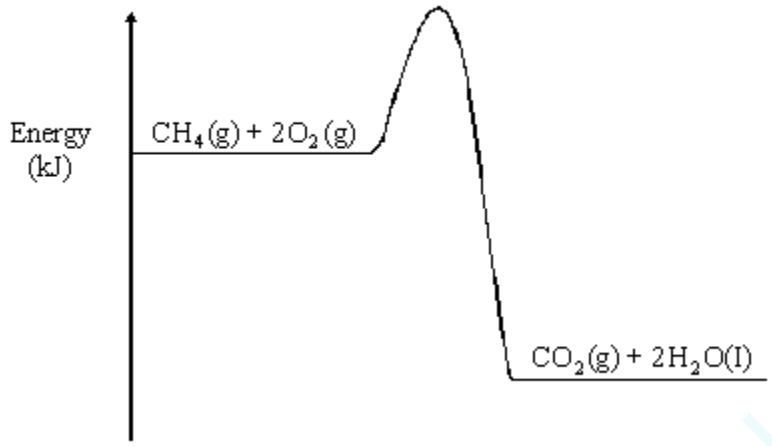


Explain the significance of **x**, **y** and **z** on the energy level diagram in terms of energy transfers that occur in the reaction. You should make specific reference to the bonds broken and formed and to the nett energy transfer (energy transferred to or from the surroundings).

(Total 6 marks)

Q14.

Many hydrocarbons are used as fuels. An energy level diagram is shown for the combustion of the hydrocarbon methane.



Describe and explain why the line rises and then falls to a lower level.

(Total 4 marks)

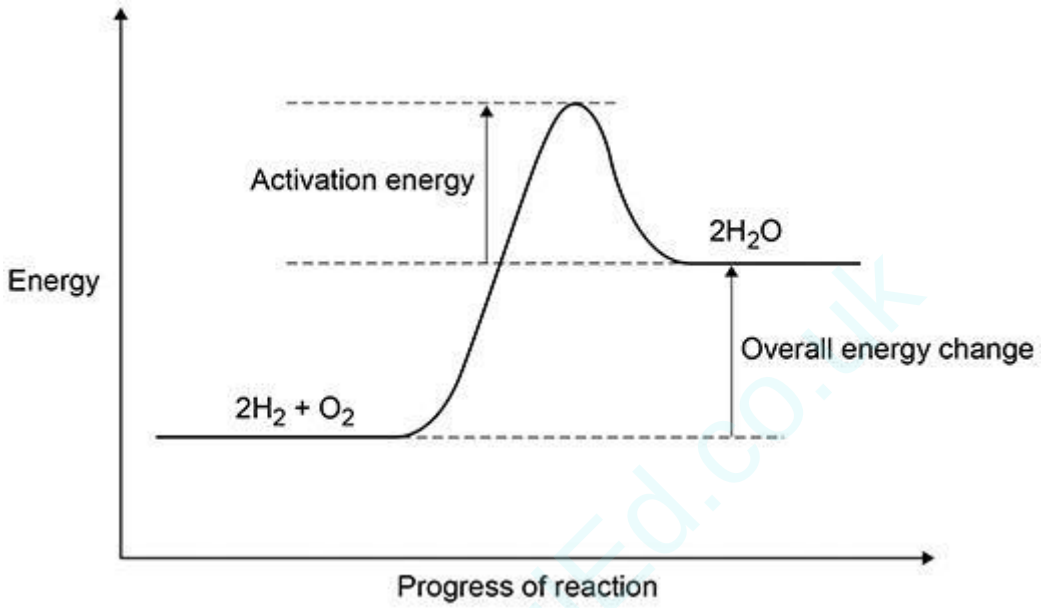
Q15.

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)

Q16.

RP4 When ammonium chloride is dissolved in water, there is a temperature change.

A student investigated how the temperature of water changed when different masses of ammonium chloride were added to the same volume of water.

The water used was at room temperature.

The student's results are shown in the table.

Mass of ammonium chloride in g	Final temperature of solution in °C
10	14.5
20	8.5
25	5.5
30	2.5
35	1.0
40	1.0
45	1.0

(a) (i) Use the correct word from the box to complete the sentence.

endothermic	exothermic	reduction

When ammonium chloride dissolves in water, the change can be

described as _____ .

(1)

(ii) Give a reason for your answer to part **(a) (i)**. Refer to the table of results in your answer.

_____

_____

(1)

(b) The student added the ammonium chloride to water and stirred the mixture.

The water was in a glass beaker.

His teacher said that using a glass beaker could cause inaccurate results.

What could the student have used instead of a glass beaker to improve the accuracy?

Give a reason why this would improve the accuracy of his results.

_____

_____

_____

_____

_____

(2)

(c) The student made sure his investigation was a fair test.

State **two** control variables the student should keep the same.

Give a reason why changing each of these two control variables would affect the temperature change.

Control variable 1 _____

Reason _____

_____

_____

Control variable 2 _____

Reason _____

_____

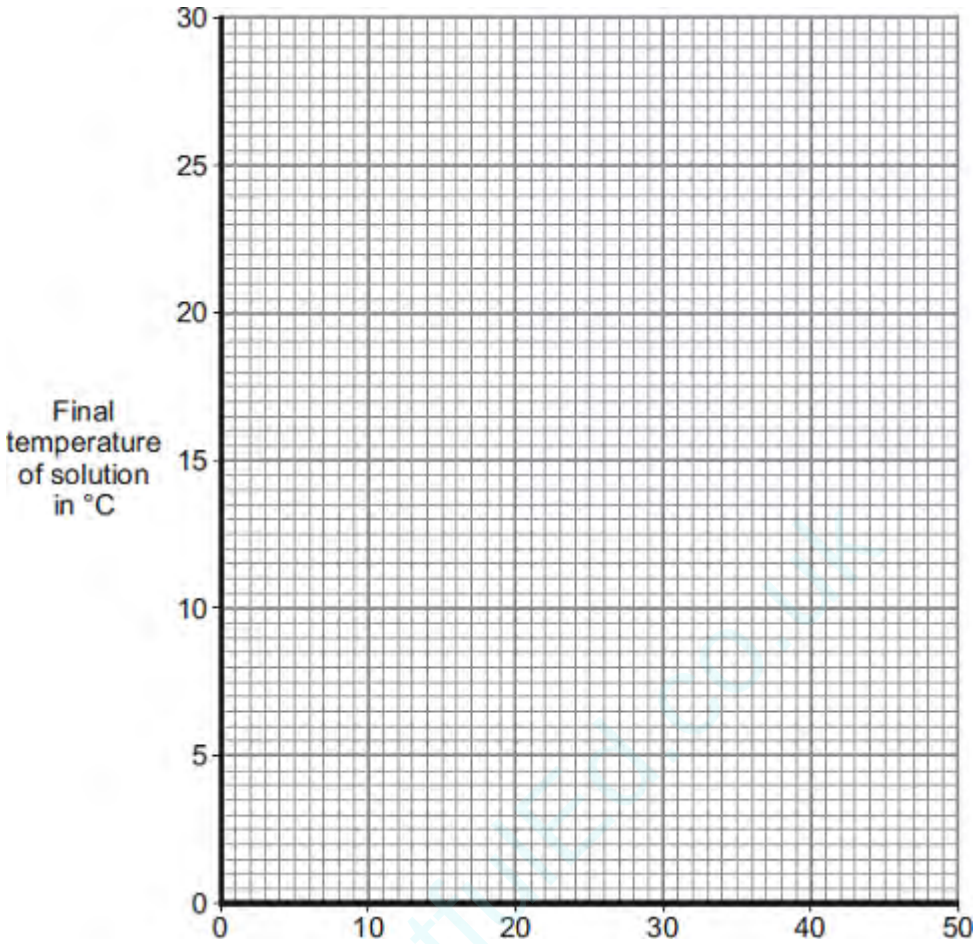
_____

(4)

(d) (i) The student's results table has been repeated below.

Mass of ammonium chloride in g	Final temperature of solution in °C
10	14.5
20	8.5
25	5.5
30	2.5
35	1.0
40	1.0
45	1.0

Plot the results on the grid.



(2)

(ii) Complete the graph by drawing two straight lines of best fit through the points.

(2)

(iii) Use the graph to estimate the temperature of the room.

Show your working on the graph.

Temperature of room = _____ °C

(2)

(e) Explain why the final temperature was the same for all masses of 35 g and greater.

_____

_____

_____

_____

(2)

(f) A second student also did one of the experiments.

This student recorded a final temperature of 14.5 °C.

Both students dissolved 20 g of ammonium chloride in water.

Use the graph to explain the difference in the two final temperatures.

_____

_____

_____

_____

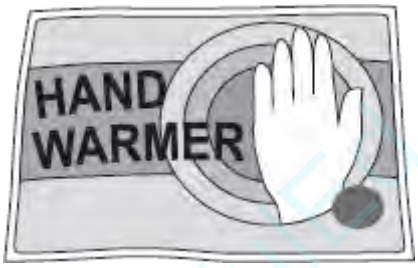
_____

(2)

(Total 18 marks)

Q17.

Hand warmers use chemical reactions.



(a) The table shows temperature changes for chemical reactions **A**, **B** and **C**.

Reaction	Starting temperature in °C	Final temperature in °C	Change in temperature in °C
A	18	25	+ 7
B	17	_____	+ 5
C	18	27	+ 9

What is the final temperature for reaction **B**? Write your answer in the table.

(1)

(b) (i) What name is given to reactions that heat the surroundings?

_____

(1)

(ii) Which reaction, **A**, **B** or **C**, would be best to use in a hand warmer?

Reaction ☐

Give a reason why you chose this reaction.

(2)

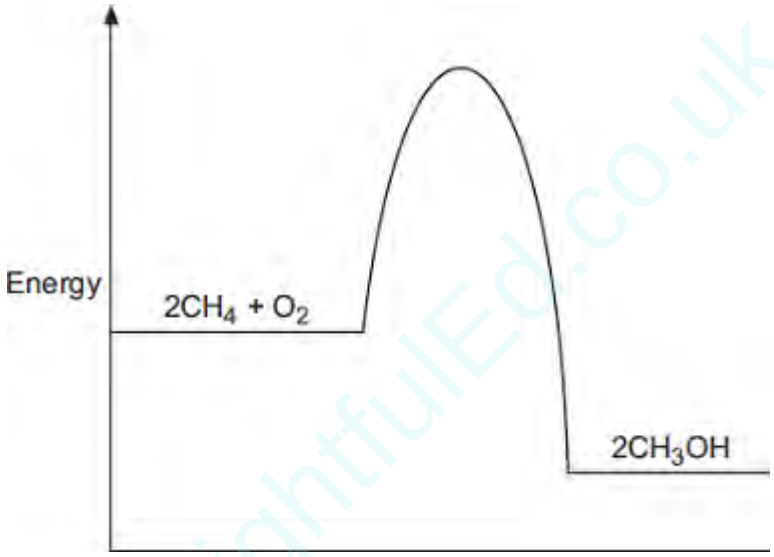
Q18.

Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2).
The reaction is exothermic.

The equation for the reaction is:

$$2CH_4 + O_2 \longrightarrow 2CH_3OH$$

(a) The energy level diagram for this reaction is given below.



(i) How does the diagram show that this reaction is exothermic?

(1)

(ii) A platinum catalyst can be used to increase the rate of this reaction.

What effect does adding a catalyst have on the energy level diagram?

(1)

Q19.

Hydrogen peroxide decomposes to give water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The reaction is *exothermic*.

(a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is *exothermic*.

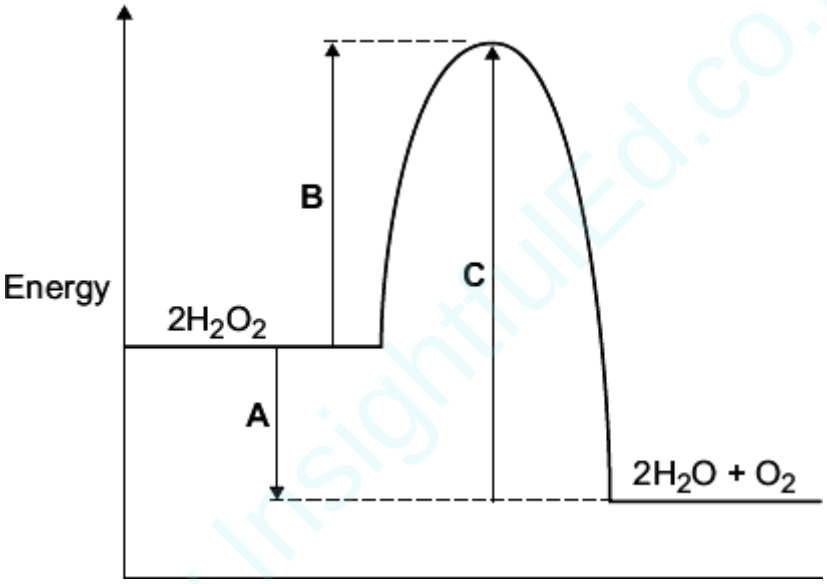
_____

_____

_____

(1)

(b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

(i) How do you know that this reaction is *exothermic*?

_____

_____

_____

(1)

(ii) The decomposition of hydrogen peroxide is slow.
What does this suggest about energy change **B**?

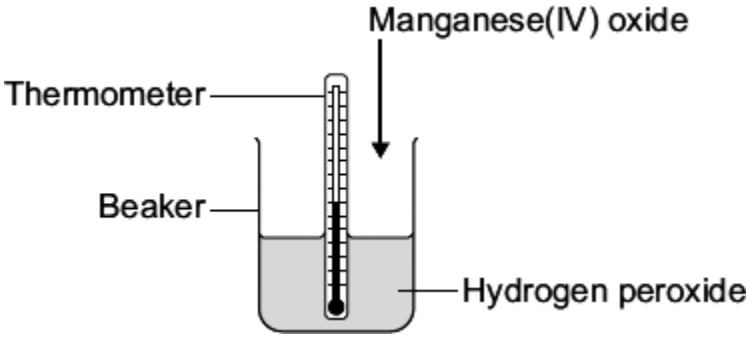
_____

_____

(1)

(c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide and recorded the highest temperature.

The temperature rise was smaller than expected.

Suggest why.

(2)

Q20.

(a) Which sub-atomic particles are present in the nucleus of an atom?

_____ and _____

(2)

(ii) Hydrogen also reacts with fluorine.

$H_2(g) + F_2(g) \longrightarrow 2\ HF(g)$ $\Delta H = -538$ kJ per mole

Draw an energy level diagram for this reaction.

Include on your diagram labels to show:

- the reactants and the products
- the overall enthalpy change (ΔH)
- the activation energy.

(3)

Q21.

This question is about displacement reactions.

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

What is meant by 'activation energy'?

_____

_____

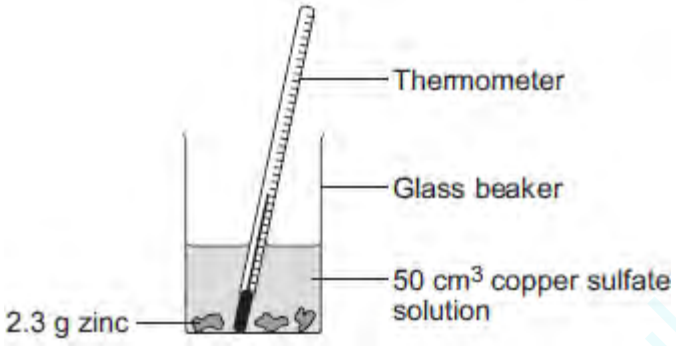
(1)

Q22.

A student investigated the temperature change when zinc reacts with copper sulfate solution.

The student used a different concentration of copper sulfate solution for each experiment.

The student used the apparatus shown below.



The student:

- measured 50 cm^3 copper sulfate solution into a glass beaker
- measured the temperature of the copper sulfate solution
- added 2.3 g zinc
- measured the highest temperature
- repeated the experiment using copper sulfate solution with different concentrations.

The equation for the reaction is:

$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$

zinc + copper sulfate solution $\longrightarrow$ copper + zinc sulfate solution

(a) The thermometer reading changes during the reaction.

Give **one** other change the student could **see** during the reaction.

_____

_____

(1)

(b) Suggest **one** improvement the student could make to the apparatus.

Give a reason why this improves the investigation.

Improvement _____

_____

Reason _____

_____

(2)

(c) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

The student's results are shown in the table below.

Experiment number	Concentration of copper sulfate in moles per dm^3	Increase in temperature in °C
1	0.1	5
2	0.2	10
3	0.3	12
4	0.4	20
5	0.5	25
6	0.6	30
7	0.7	35
8	0.8	35
9	0.9	35
10	1.0	35

Describe **and** explain the trends shown in the student's results.

(6)

(Total 9 marks)

Q1.

(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

(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]

Q2.

(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

(e) use the same mass of metal / powder

1

(f) (A) progress of reaction

1

(B) activation energy

1

(C) products

1

[9]

Q3.

(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

Q4.

(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]

Q5.

(a) measuring cylinder

1

(b) use a polystyrene cup
allow insulate the beaker and / or use a lid

1

better insulator

or

reduces energy transfer from the surroundings

1

(c) starting temperature of hydrochloric acid

1

volume of hydrochloric acid

1

(d) 21.4 (°C)

1

(e) 15.8 (°C) to 16.1 (°C)
allow 16.1 (°C) to 15.8 (°C)

1

(f) $\frac{16.1 - 15.8 - 15.9}{3}$

=15.9 (°C)
*an answer of 15.9(333..) (°C) scores **2** marks*

1

allow 15.9(333..) (°C)

1

(g) temperature decreases

1

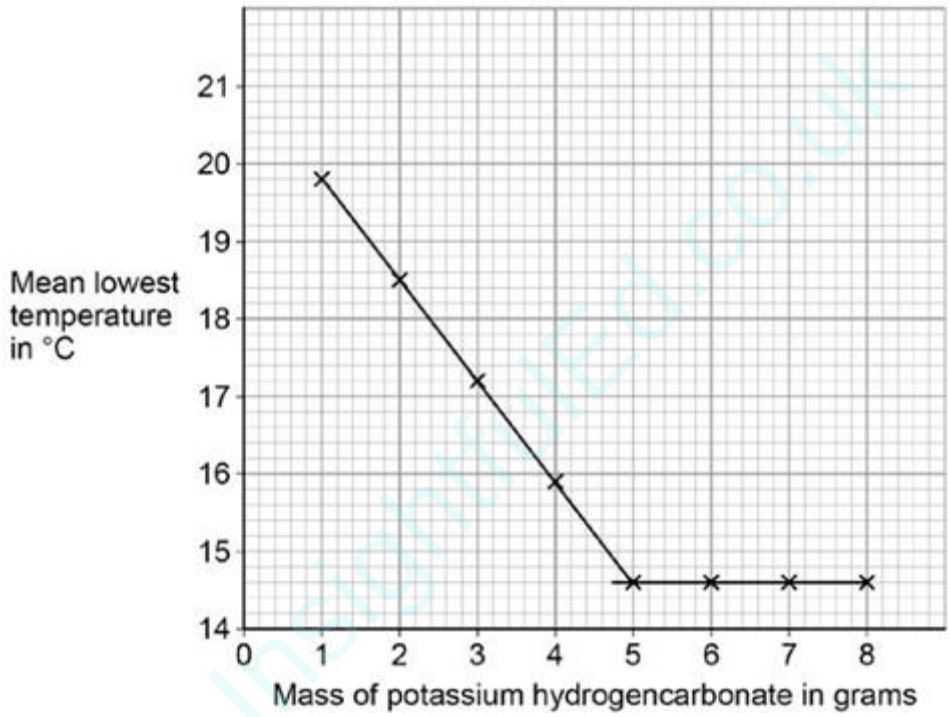
(h) straight line from (1.0, 19.8) to (5.0, 14.6)
ignore continuation of line in either direction

1

horizontal straight line from (5.0, 14.6 to 8.0, 14.6)
ignore continuation of line in either direction

1

the answer below scores **2** marks



(i) (lowest) temperature decreases

1

to 14.6 °C
or
until 5 g added

1

then no change to temperature (after 5 g solid added)
or
then temperature remains at 14.6 °C (after 5 g solid added)

1

[15]

Q6.

(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]

Q7.

(d) B

1

(e) A

1

(f) exothermic

1

Q8.

(a) (i) 5.75 **or** 5.8

*correct answer with or without working gains **2** marks*
*correct working showing addition of any four results and division by 4 gains **1** mark*
OR
*6(.04) for **1** mark*

2

(ii) use a polystyrene cup **or** lid

accept insulate the beaker

1

to prevent energy/heat gain

accept to prevent energy/heat transfer
*do **not** accept energy/heat loss*

OR

use a digital thermometer

allow use a data logger

easier to read (to 0.1°C)

1

(b) (as mass increases) the final temperature increases

1

then stays constant

1

correct reference to a value above 8 g up to and including 10 g as mass when the trend changes

1

[7]

Q9.

(a) water / H_2O

allow steam or hydrogen oxide

1

(b) (i) A

1

(ii) exothermic

1

products (energy) lower than reactants (energy)

1

Q10.

(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

Q11.

(a) the bag gets cold because heat energy is taken in from the surroundings

1

(b) endothermic

1

(c) any **two** from:

- mix / spread (the ammonium nitrate and water)
- dissolve faster(*)
- get cold faster **or** so the whole bag gets cold(*)

  *(*)allow increase rate **or** quicker reaction*
- particles collide more **or** more collisions

2

[4]

Q12.

(a) breaking of C-H bonds
breaking of O-O bonds
making of C-O bonds

for 1 mark each

making of H-O bonds

4

(b) X energy needed to break bonds
has to be **supplied**/activation energy

Y energy released when bonds form

Z = Y-X
overall, energy is released/reaction is exothermic
each for 1 mark

5

[9]

Q13.

ideas that

- x = the energy required / taken in / used* to break the bonds of water / reactant [*not used up / formed]
  gains 1 mark

- **but =** the energy required taken in / used to break the bonds in water **or** activation energy
  gains 2 marks

- y = the energy released given out when bonds form
  gains 1 mark

- **but =** the energy released / given out when hydrogen / oxygen form
  gains 2 marks

- z = 1856 – 1370 or (+)486 kJ
  for 1 mark

or difference between x and y **or** net energy transferred

- overall, energy is taken in / absorbed in the reaction **or** the reaction is endothermic **or** energy required to break existing bonds is > energy released when new bonds form
  for 1 mark

[6]

Q14.

rises as energy needed for bond breaking (of reactants)

1

called activation energy **or** correctly labelled on diagram

1

bond making (to form products) releases energy

1

called exothermic reaction **or** more energy given out than taken in **or** releases heat to the surroundings

1

[4]

Q15.

(a) the activation energy should be from the reactants (line to the peak)

ignore description of where the activation energy is on the diagram

1

the products (line) should be below the reactants (line)
or
the products should have less energy than the reactants

allow the product (line) is above the reactants (line)

allow the products have more energy than the reactants allow the profile shows an endothermic reaction

ignore the arrow for the overall energy change should point downwards

1

Q16.

(a) (i) endothermic

could be answered by indicating the correct word in the box

1

(ii) final temperatures got lower **or** temperature went down

ignore comments on energy

1

(b) polystyrene / plastic cup **or** description of insulation / lagging container

ignore references to a lid

1

because (polystyrene) is an insulator **or** prevents heat / energy gain (and so temperature is more accurate)

*allow references to heat loss **or** glass conducts / absorbs heat*

1

(c) **variable**: volume **or** mass **or** amount of water

***1** mark for variable and **1** mark for reason linked to that variable*

*maximum of **4** marks for two variables and two explanations*

reason: the greater the volume / mass of water, the more heat energy it contains **or** the smaller the temperature change will be

*do **not** allow 'time taken to heat'*

variable: start temperature **or** temperature of water

reason: the higher the start temperature, the more heat energy it contains **or** the higher the final temperature will be

*do **not** allow higher temperature change*

variable: the time at which the temperature is measured

reason: if left longer may gain heat energy from surroundings **or** warm up **or** if measured too soon not all ammonium chloride will have dissolved so less temperature change

variable: rate of dissolution **or** speed of dissolving **or** amount of stirring

reason: if it dissolves faster **or** is stirred faster then it will cool more quickly **or** small particles dissolve faster

max. 4

(d) (i) all 7 points correct

*at least 4 points plotted correctly scores **1** mark*

2

(ii) straight line through first 3 or 4 points

lines must be drawn with a ruler

1

straight line through last three points

*if no other marks awarded allow curve joining lines for **1** mark*

1

(iii) valid extrapolation of line back to mass of 0 g

1

correct value read from graph

*award **1** mark for 20 − 21 if no extrapolation shown*

1

(e) not all of the ammonium chloride would dissolve

*allow water limiting factor **or** all water used*

1

so no more heat would be absorbed

or

the solution is saturated (1)

*allow water limiting factor **or** all water used*

so some ammonium chloride remains solid **or** not all will dissolve (1)

1

(f) greater volume of water was used **or** volume was twice as large

allow different volume of water

1

so temperature decrease was less than the first student's result

allow so final temperature was higher

or

starting temperature / room temperature was higher (1)

so final temperature was greater than the first student's result (1)

*accept by 6 °C **or** was any value in range 26 − 27°C*

1

[18]

Q17.

(a) 22

1

(b) (i) exothermic

1

(ii) C

1

gives out most heat energy

accept has largest temperature change / increase

*allow has highest (final) temperature **or** hottest*

1

Q18.

(a) (i) energy / heat of products less than energy of reactants

allow converse

allow products are lower than reactants

allow more energy / heat given out than taken in

allow methanol is lower

allow energy / heat is given out / lost

allow ΔH is negative

1

(ii) lowers / less activation energy

allow lowers energy needed for reaction
***or** it lowers the peak/ maximum*

*do **not** allow just 'lowers the energy'*

1

(b) (i) (8 × 435) + 497 = 3977

accept: bonds broken: (2 × 435) + 497 = 1367

1

(6 × 435) + (2 × 336) + (2 × 464) = 4210

bonds made: (2 × 336) + (2 × 464) = 1600

1

3977 – 4210 = (–) 233

energy change:

1367 – 1600 = (–) 233

ignore sign

allow ecf

*correct answer (233) = **3** marks with or without working*

1

(ii) energy released forming (new) bonds is greater than energy needed to break (existing) bonds

allow converse

*do **not** accept energy needed to form (new) bonds greater than energy needed to break (existing) bonds*

1

[6]

Q19.

(a) energy released from making (new) bonds is greater than the energy needed to break (existing) bonds

accept the energy needed to break (existing) bonds is less than the energy released in making (new) bonds

*do **not** accept energy needed to make bonds*

1

(b) (i) energy / heat of products less than energy of reactants

accept products are lower than reactants

***or** reactants higher than products*

accept more energy / heat given out than taken in

***or** less energy / heat taken in than given out*

accept energy / heat is given out / lost (to the surroundings)

allow produce heat

ignore produce energy

accept ΔH is negative

***or** energy change / **A** is negative*

or B** is less than **C

1

(ii) **B** is (very) high / large

*it = **B***

*ignore energy change **C** is high*

1

(c) any **two** from:

- (chemicals) not mixed / stirred
- heat / energy lost (from apparatus)
- (apparatus) not insulated **or** no lid
- low amount / mass / not enough MnO_2 **or** low concentration H_2O_2
- thermometer read incorrectly

ignore other experimental error

2

[7]

Q20.

(a) neutron(s)

answers can be in either order

1

proton(s)

1

(b) same number (17) protons **or** same number electrons

if candidate chooses to quote numbers, they must be correct

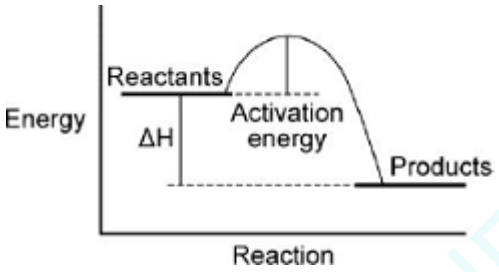
1

different numbers of neutrons (^{35}Cl has 18 and ^{37}Cl has 20)

1

(c)

(ii)



the reactants and the products at the correct level

ignore labels on the axes

1

ΔH correctly labelled

allow −538 if in correct place

1

E_a correctly labelled

*correctly labelled endothermic reaction gains max. **2** marks*

1

[10]

Q21.

(a) the (minimum) energy needed for particles to react

or

the (minimum) energy needed for a reaction to occur

allow the (minimum) energy needed to start a reaction

1

Q22.

(a) any **one** from:

- solution becomes colourless or colour fades
- zinc becomes bronze / copper coloured
  allow copper (forms) or a solid (forms)
- zinc gets smaller
  allow zinc dissolves
- bubbles or fizzing.
  ignore precipitate

1

(b) improvement:
use a plastic / polystyrene cup or add a lid
accept use lagging / insulation

1

reason - must be linked
reduce / stop heat loss
OR
improvement:

use a digital thermometer
allow use a data logger

reason - must be linked

more accurate or easy to read or stores data
allow more precise or more sensitive
ignore more reliable
ignore improvements to method, eg take more readings

1

(c) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking Guidance and apply a 'best–fit' approach to the marking.

0 marks
No relevant content

Level 1 (1−2 marks)
There is a statement about the results.

Level 2 (3−4 marks)
There are statements about the results. These statements may be linked or may include data.

Level 3 (5−6 marks)
There are statements about the results with at least one link and an attempt at an explanation.

Examples of chemistry points made in the response:

Description:

Statements

Concentration of copper sulfate increases

Temperature change increases

There is an anomalous result

The temperature change levels off

Reaction is exothermic

Linked Statements

Temperature change increases as concentration of copper sulfate increases

The temperature change increases, and then remains constant

After experiment 7 the temperature change remains constant

Statements including data

The trend changes at experiment 7

Experiment 3 is anomalous

Attempted Explanation

Temperature change increases because rate increases

Temperature change levels off because the reaction is complete

Explanation

As more copper sulfate reacts, more heat energy is given off

Once copper sulfate is in excess, no further heat energy produced

6

[9]