All questions are for both separate science and combined science students

Q1.

This question is about energy changes of reactions.

Zinc reacts with copper sulfate solution.

The word equation for the reaction is:

zinc + copper sulfate → zinc sulfate + copper

(a) What type of reaction is the reaction between zinc and copper sulfate solution?

Tick (✓) **one** box.

Combustion ☐

Decomposition ☐

Displacement ☐

(1)

(b) Calculate the percentage (%) by mass of copper in copper sulfate (CuSO4).

Give your answer to 3 significant figures.

Relative atomic mass (*Ar*): Cu = 63.5

Relative formula mass (*Mr*): $CuSO_4$ = 159.5

_____

_____

_____

_____

_____

Percentage by mass (3 significant figures) = _____ %

(3)

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

This is the method used.

1. Measure 25 cm^3 of copper sulfate solution into a polystyrene cup.

2. Weigh 0.20 g of zinc powder.

3. Add the zinc powder to the copper sulfate solution.

4. Measure the highest temperature reached by the mixture.

5. Repeat steps 1 to 4 using different masses of zinc powder.

(c) Control variables are used to make an investigation a fair test.

Which is a control variable in the investigation?

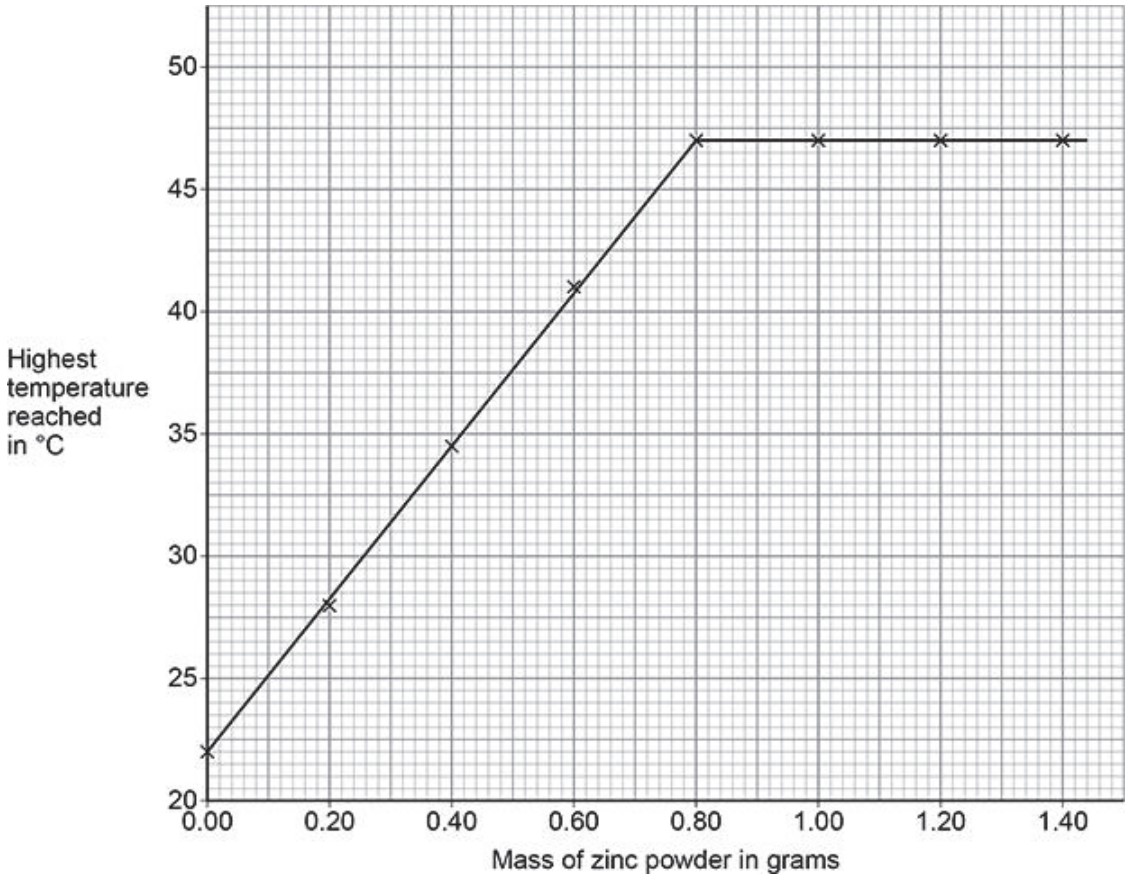
Tick (✓) **one** box.

- Highest temperature reached by the mixture ☐
- Mass of zinc powder ☐
- Volume of copper sulfate solution ☐

(1)

Figure 1 shows the results.

Figure 1



(d) What is the minimum mass of zinc powder needed to react with all the copper sulfate solution?

Use **Figure 1**.

Minimum mass of zinc powder = _____ g

(1)

(e) What is the maximum temperature change in the reaction between zinc powder and 25 cm^3 of copper sulfate solution?

Use **Figure 1**.

_____

_____

_____

Maximum temperature change = _____ °C

(2)

(f) 25 cm^3 of copper sulfate solution contained 6.75 g of copper sulfate.

Calculate the concentration of the solution in g/dm^3.

You should:

- calculate the volume of the solution in dm^3 (1000 cm^3 = 1 dm^3)
- use the equation:

$$\text{concentration of solution in g/dm}^3 = \frac{\text{mass of copper sulfate in grams}}{\text{volume of solution in dm}^3}$$

_____

_____

Volume of solution = _____ dm^3

_____

_____

_____

Concentration of solution = _____ g/dm^3

(3)

Another student investigated the energy change of the reaction between sodium hydrogencarbonate and hydrochloric acid.

This is the method used.

1. Measure 25 cm^3 of hydrochloric acid.

2. Weigh 1.0 g of sodium hydrogencarbonate.

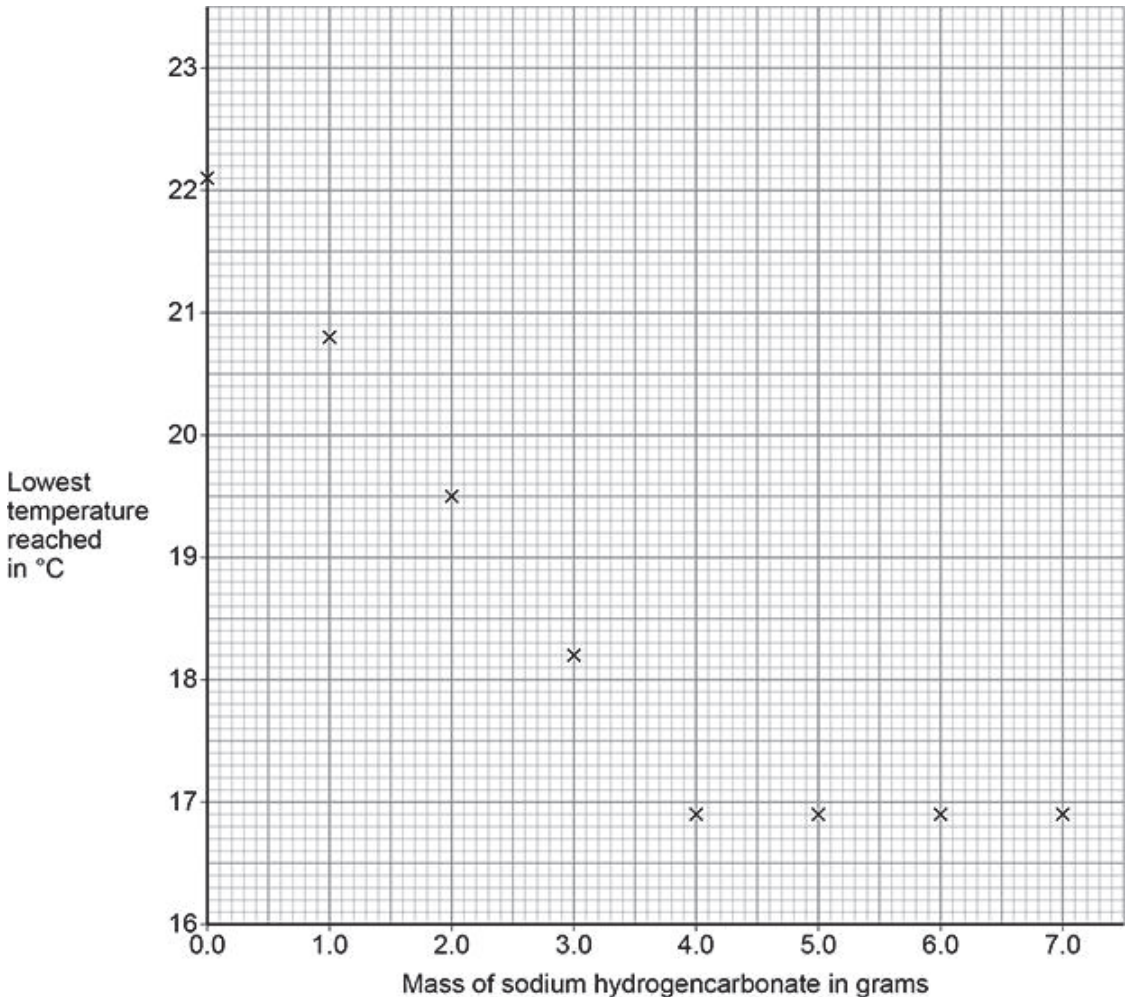
3. Add the sample of sodium hydrogencarbonate to the hydrochloric acid.

4. Measure the lowest temperature reached by the mixture.

5. Repeat steps 1 to 4 using different masses of sodium hydrogencarbonate.

Figure 2 shows the results.

Figure 2



(g) Draw **two** straight lines of best fit on **Figure 2**.

The lines should cross.

(2)

(h) Which statement describes the energy change in the reaction shown in **Figure 2**?

Tick (✓) **one** box.

Energy is **transferred to** the surroundings so the reaction is **endothermic**. ☐

Energy is **transferred to** the surroundings so the reaction is **exothermic**. ☐

Energy is **taken in from** the surroundings so the reaction is **endothermic**. ☐

Energy is **taken in from** the surroundings so the reaction is **exothermic**. ☐

(1)

(Total 14 marks)

Q2.

This question is about temperature changes.

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

This is the method used.

1. Measure 200 cm^3 of water into a polystyrene cup.

2. Measure the temperature of the water.

3. Add 4.0 g of ammonium nitrate to the water.

4. Stir the solution until all the ammonium nitrate has dissolved.

5. Measure the lowest temperature reached by the solution.

6. Repeat steps 1 to 5 with different masses of ammonium nitrate.

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

Independent variable _____

Dependent variable _____

(2)

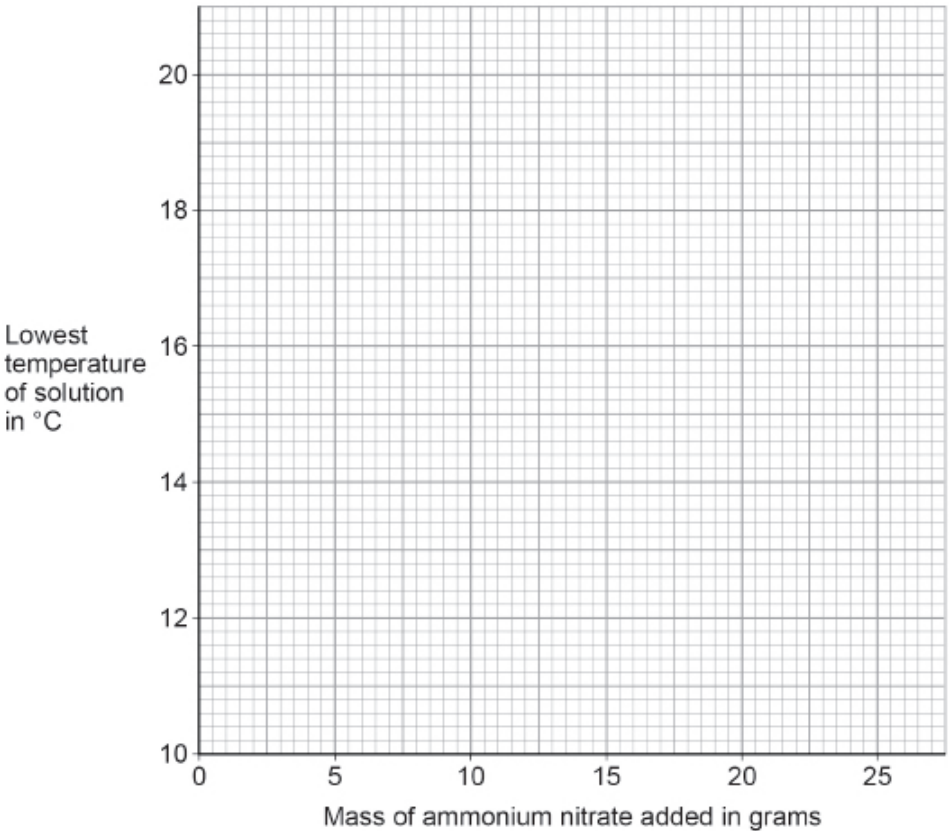
Table 1 shows the results.

Table 1

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

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

Draw a line of best fit.



(3)

(c) Determine the initial temperature of the water.

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

Initial temperature of the water = _____ °C

(2)

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

_____

_____

(1)

The student repeated the experiment three more times.

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

Table 2

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Mean**
Lowest temperature of solution in ºC	16.2	16.6	16.8	16.4	16.5

(e) The student recorded the mean lowest temperature of the solution for 8.0 g of ammonium nitrate as 16.5 ± 0.3 ºC.

Explain why the student included ± 0.3 ºC after the mean lowest temperature.

_____

_____

_____

_____

(2)

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

Tick (✓) **one** box.

Random error ☐

Systematic error ☐

Zero error ☐

(1)

(Total 11 marks)

Q3.

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.

_____

_____

_____

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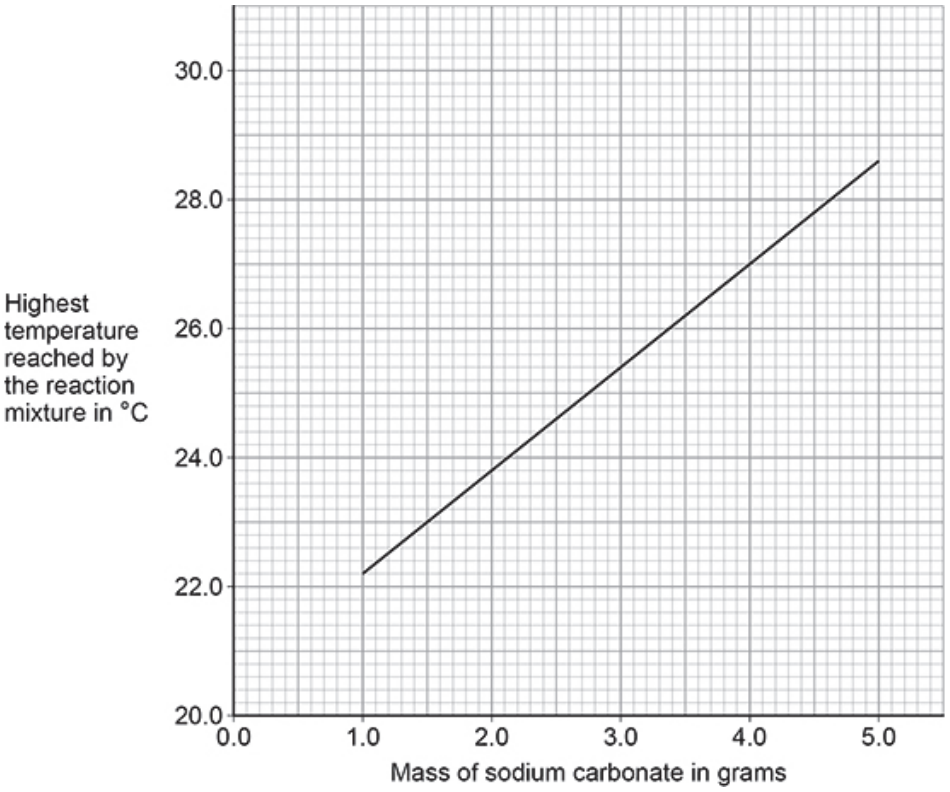
_____

(6)

Figure 1 shows a line of best fit drawn through the student's results.

Figure 1



(b) Determine the gradient of the line of best fit in **Figure 1**.

Use the equation:

$$\text{Gradient} = \frac{\text{Change in highest temperature}}{\text{Change in mass}}$$

Give the unit.

_____

_____

_____

_____

_____

_____

_____

_____

Gradient = _____ Unit _____

(5)

(c) The initial temperature of the reaction mixture is where the line of best fit would meet the *y*-axis.

Determine the initial temperature of the reaction mixture.

Show your working on **Figure 1**.

Initial temperature of the reaction mixture = _____ °C

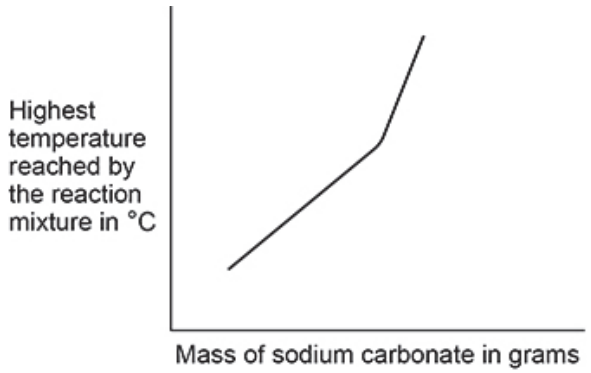
(2)

(d) 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?

Tick (✓) **one** box.

A



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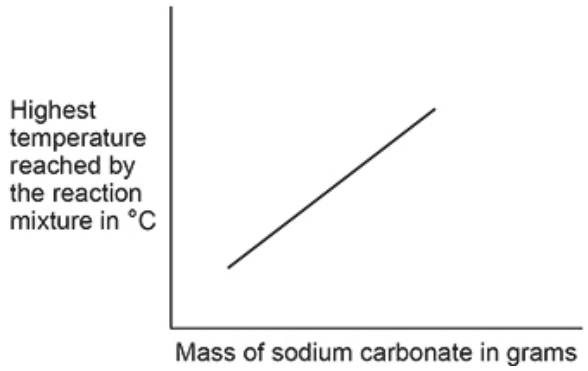
B



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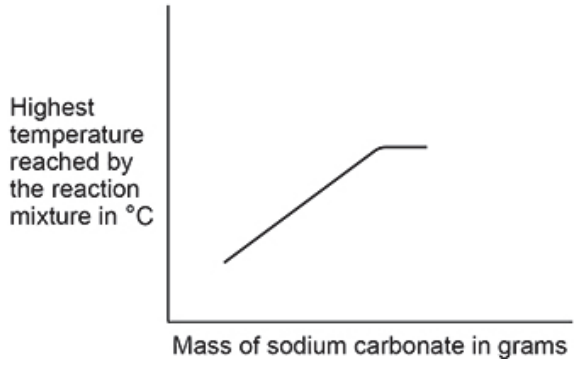
C

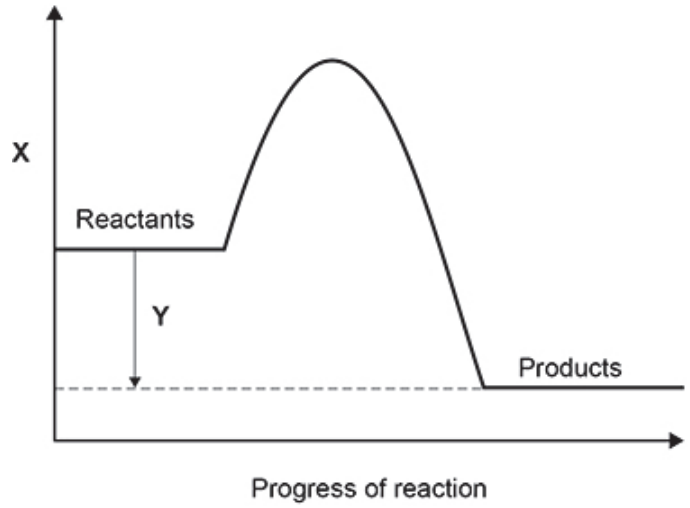


☐

(1)

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)