1 Zinc is added to dilute hydrochloric acid. The equation for the reaction is

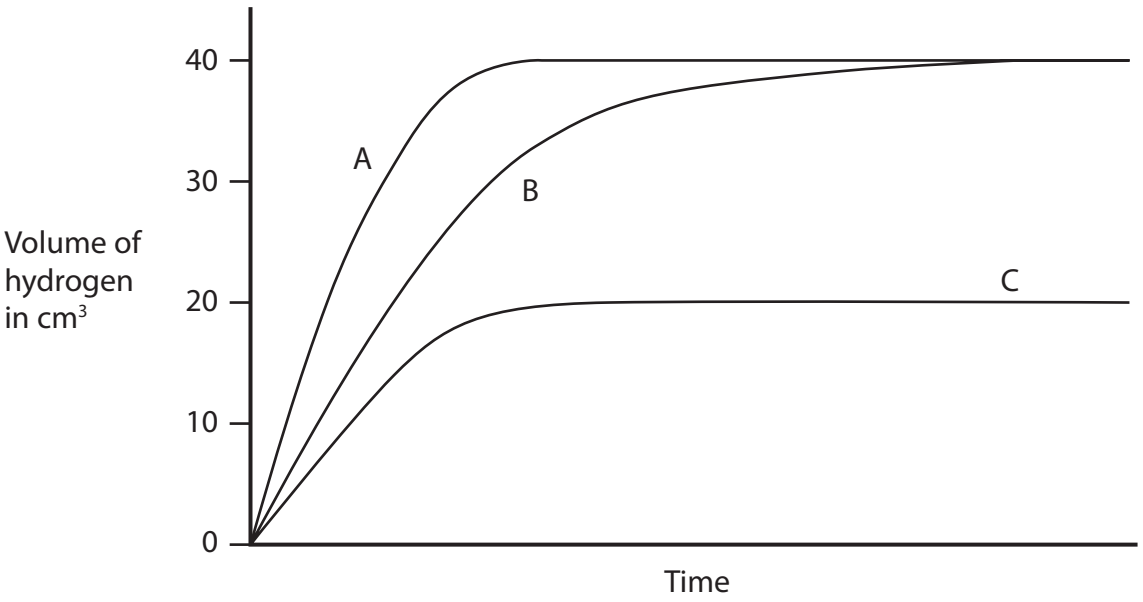
$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

An experiment is carried out using

- 0.12 g of powdered zinc
- an excess of 0.2 mol/dm^3 hydrochloric acid
- a temperature of 20 °C

The volume of hydrogen collected in the experiment is measured at regular time intervals.

Curve B shows the results obtained.



(a) The experiment is repeated using

- 0.12 g of powdered zinc
- an excess of 0.2 mol/dm^3 hydrochloric acid
- a temperature of 40 °C

Explain which curve, A, B or C, shows the results obtained.

(3)

(b) The experiment is repeated again, using

- 0.06 g of powdered zinc
- an excess of 0.2 mol/dm^3 hydrochloric acid
- a temperature of 20 °C

Explain which curve, A, B or C, shows the results obtained.

(3)

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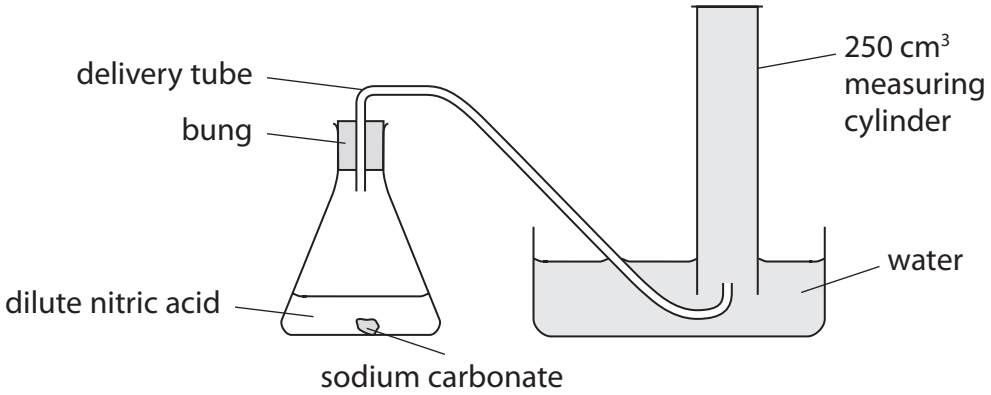
(Total for Question 1 = 6 marks)

2 A student uses this apparatus to determine the volume of one mole of carbon dioxide gas.



This is the student's method.

- a solid lump of sodium carbonate of mass 0.53 g is placed into the conical flask
- an excess of dilute nitric acid is added and the bung is put in place
- when all of the sodium carbonate has reacted, the volume of carbon dioxide collected is measured

The equation for the reaction is

$$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$$

(a) (i) Calculate the amount, in moles, of sodium carbonate that reacts.
[M_r: Na_2CO_3 = 106]

(2)

amount of sodium carbonate = ... mol

(ii) The volume of carbon dioxide collected is 110 cm^3.

Use this information and your answer to (a)(i) to calculate the volume, in cm^3, of one mole of carbon dioxide.

(2)

volume of one mole of carbon dioxide = ... cm^3

(b) The correct value for the volume of one mole of carbon dioxide, under the conditions used in the experiment, is 24000 cm^3.

Suggest two reasons why the volume calculated from the experiment is less than the correct value.

(2)

1 .....

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2 .....

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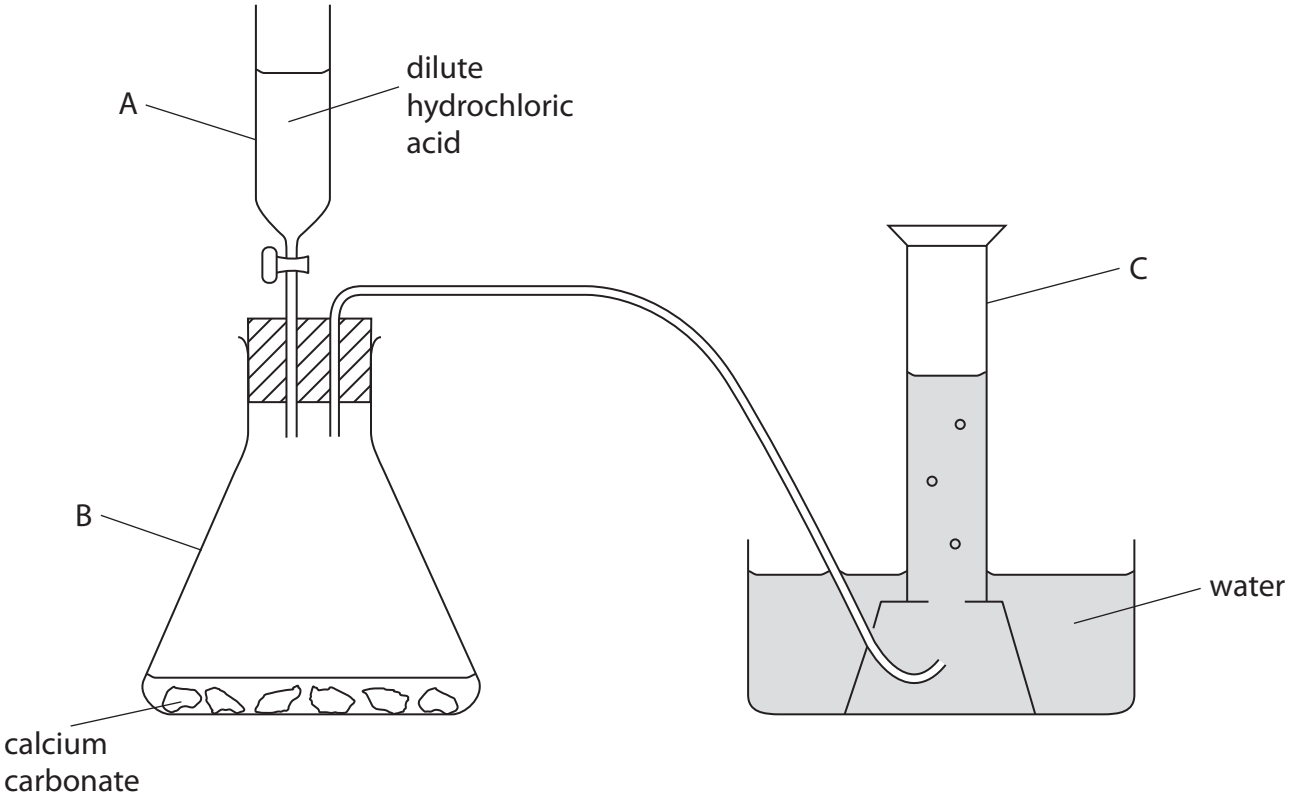
(Total for Question 2 = 6 marks)

3 This apparatus can be used to make and collect carbon dioxide.

This is done by adding dilute hydrochloric acid to calcium carbonate.



(a) Give the names of the pieces of apparatus labelled A, B and C.

(3)

A .....

B .....

C .....

(b) When an excess of carbon dioxide is bubbled through limewater, reaction 1 occurs, followed by reaction 2.

The equations for these reactions are

reaction 1 $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

reaction 2 $CaCO_3(s) + H_2O(l) + CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$

Suggest two observations that would be made when excess carbon dioxide is bubbled through limewater.

(2)

1 .....

.....

2 .....

.....

(c) Carbon dioxide is used in some fire extinguishers because it does not support combustion.

State another property of carbon dioxide that makes it suitable for use in fire extinguishers.

(1)

.....

.....

(d) Carbon dioxide is slightly soluble in water. The solution formed has a pH of 5.6

Which is the best description of a solution of carbon dioxide in water?

(1)

- ☒ **A** strongly acidic
- ☒ **B** strongly alkaline
- ☒ **C** weakly acidic
- ☒ **D** weakly alkaline

(Total for Question 3 = 7 marks)

4 Magnesium reacts with dilute hydrochloric acid. The equation for the reaction is

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) 0.0960 g of magnesium was added to 25.0 cm^3 of 0.400 mol/dm^3 hydrochloric acid.

(i) Calculate the amount, in moles, of magnesium used.

(2)

amount of magnesium = ... mol

(ii) Calculate the amount, in moles, of HCl in the 25.0 cm^3 of hydrochloric acid.

(2)

amount of HCl = ... mol

(b) Use your answers from (a) to determine which of the reactants is in excess.

Show your reasoning.

(2)

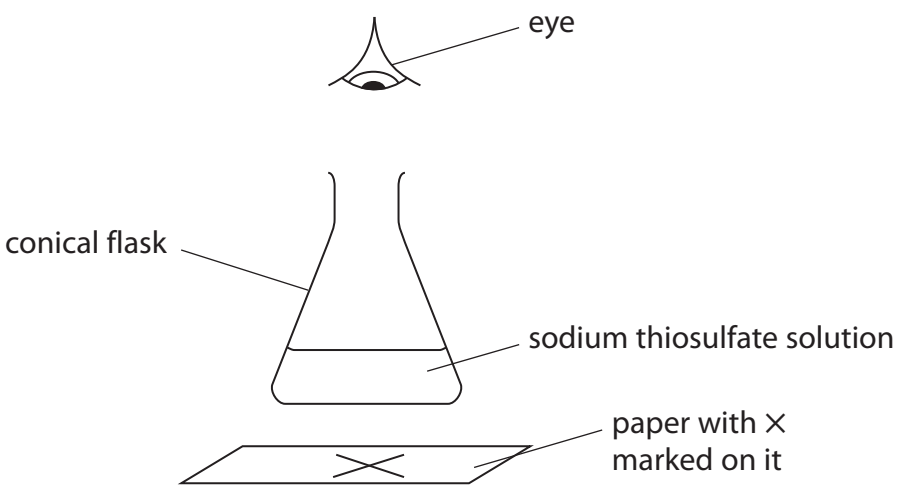
The reactant in excess is .....

(Total for Question 4 = 6 marks)

5 Sodium thiosulfate solution and dilute hydrochloric acid react together slowly to form a precipitate of sulfur. This precipitate eventually makes the mixture go cloudy.

A student uses this method.

- place 20 cm^3 of sodium thiosulfate solution and 20 cm^3 of water in a conical flask
- add 10 cm^3 of dilute hydrochloric acid to the flask
- place the flask on a piece of paper marked with a black ×
- time how long it takes before the × can no longer be seen



(a) The equation for the reaction is

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + S(s) + SO_2(g)$$

Before starting her experiments, the student considers the risk to her of sulfur dioxide escaping from the flask. She uses this information.

concentration of sodium thiosulfate solution = 0.300 mol/dm^3

volume of sodium thiosulfate solution = 20 cm^3

volume of water = 20 cm^3

volume of hydrochloric acid = 10 cm^3

(i) Calculate the mass of sulfur dioxide formed in this experiment.
The hydrochloric acid is in excess.

(3)

mass of sulfur dioxide formed = ... g

(ii) The solubility of sulfur dioxide at room temperature is 100 g/dm^3.

Use this additional information to explain whether any sulfur dioxide gas escapes from the flask.

(2)

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(b) At what point in the experiment should the student have started a timer?

(1)

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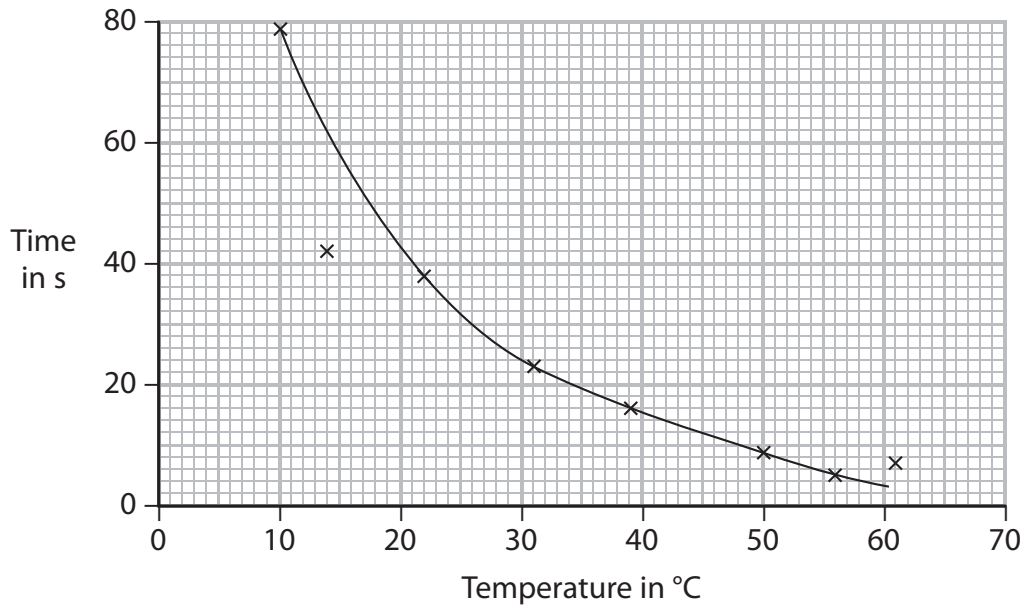
(c) She repeats the experiment using the same volumes and concentrations of solutions, but at different temperatures. The graph shows her results.



(i) The result at (14, 42) is anomalous.

Explain one mistake the student may have made to cause this anomalous result.

(1)

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(ii) Use the graph to find the time taken for the × to be no longer seen at 35 °C.

(1)

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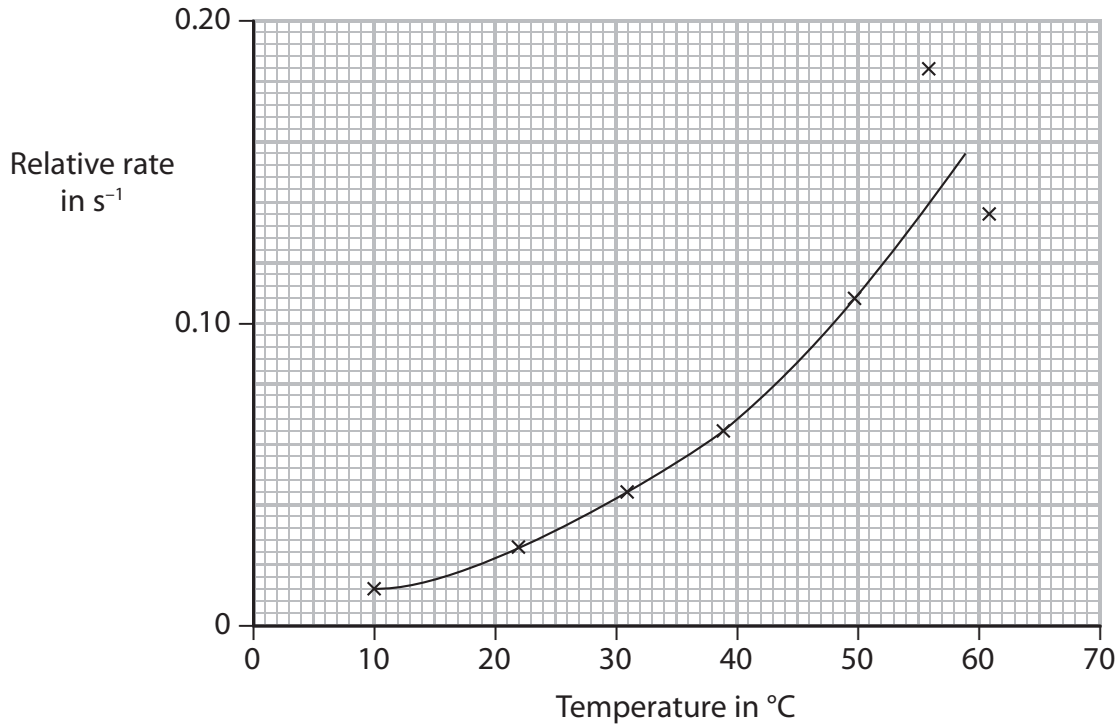
(d) The student repeats the experiments using nitric acid in place of hydrochloric acid. She records the times for the × to no longer be seen, then uses the times to calculate the rate of reaction at each temperature.
The graph shows the results she plots.



(i) Suggest two reasons why the results are least accurate at higher temperatures.

(2)

1 .....

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2 .....

.....

(ii) The student wrote this explanation for the shape of the graph.

As the temperature increases, the rate of reaction increases. This is because there are more frequent collisions between particles of reactants.

Use the particle collision theory to explain another more important reason for the increase in reaction rate.

(2)

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(e) Another student uses the same reaction to investigate the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

Give three variables that the student must control in this investigation to obtain valid results.

(3)

1 .....

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2 .....

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3 .....

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(Total for Question 5 = 15 marks)