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

Q1.

This question is about acids and alkalis.

(a) Which ion do acids produce in aqueous solution?

Tick (✓) **one** box.

H^+ ☐ OH^- ☐ O^{2-} ☐

(1)

(b) Acids react with alkalis.

What is the name of this type of reaction?

Tick (✓) **one** box.

Decomposition ☐

Electrolysis ☐

Neutralisation ☐

Redox ☐

(1)

(c) Balance the equation for the reaction between sulfuric acid and potassium hydroxide.

$$H_2SO_4 + \_\_\_\_ KOH \rightarrow K_2SO_4 + \_\_\_\_ H_2O$$

(1)

(d) Universal indicator turns purple in potassium hydroxide solution.

What is the pH of the solution?

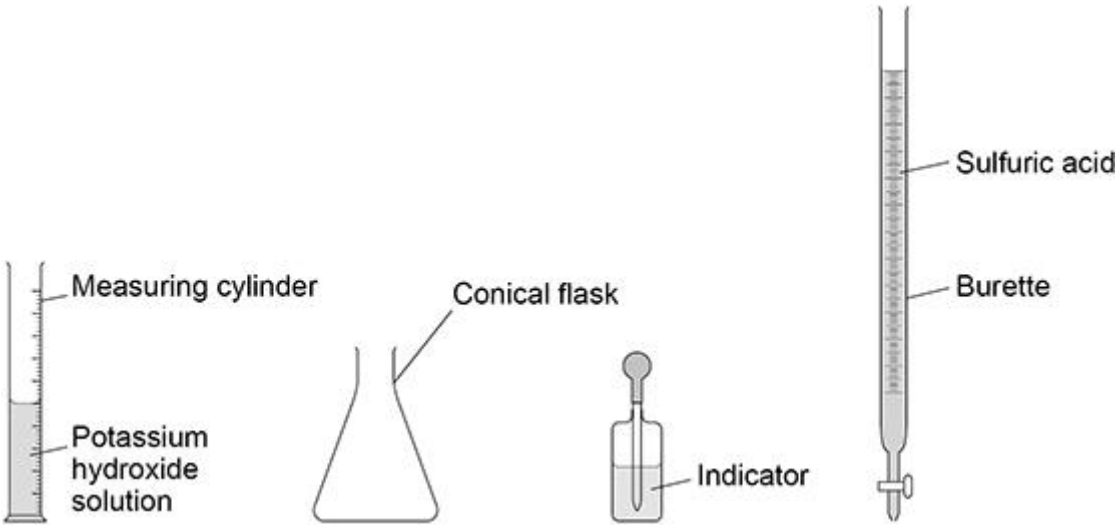
Tick (✓) **one** box.

1 ☐ 4 ☐ 7 ☐ 14 ☐

(1)

A student does a titration to find the volume of sulfuric acid that reacts with 25 cm^3 of potassium hydroxide solution.

The figure below shows the equipment used.



(e) The 25 cm^3 of potassium hydroxide solution is measured with the measuring cylinder.

Which piece of equipment could the student use to measure the 25 cm^3 of potassium hydroxide solution more accurately?

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

Beaker	☐
Evaporating basin	☐
Pipette	☐
Test tube	☐

(1)

(f) Describe how the student would use the equipment in the figure above to complete the titration. **(separate only)**

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 10 marks)

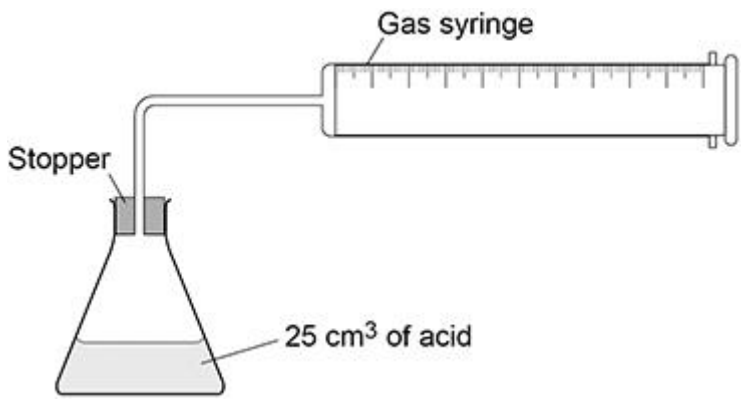
Q2.

This question is about metal carbonates.

A student investigated the reaction of copper carbonate with an acid.

Figure 1 shows the apparatus.

Figure 1

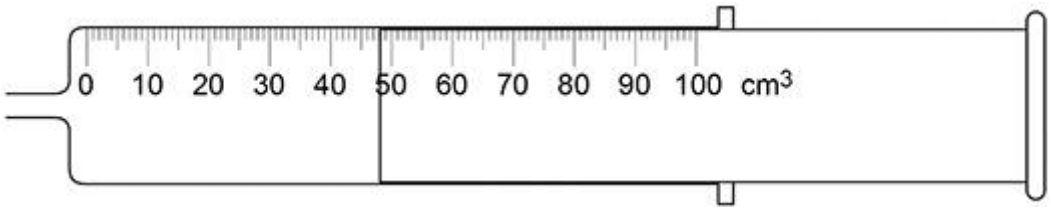


This is the method used.

1. Pour 25 cm^3 of the acid into a conical flask.
2. Weigh 0.10 g of copper carbonate.
3. Remove the stopper and add the copper carbonate to the flask.
4. Quickly replace the stopper.
5. Record the maximum volume of gas collected in the gas syringe.
6. Repeat steps 1 to 5 with different masses of copper carbonate.

(a) **Figure 2** shows the gas syringe during the experiment.

Figure 2



What is the reading on the gas syringe?

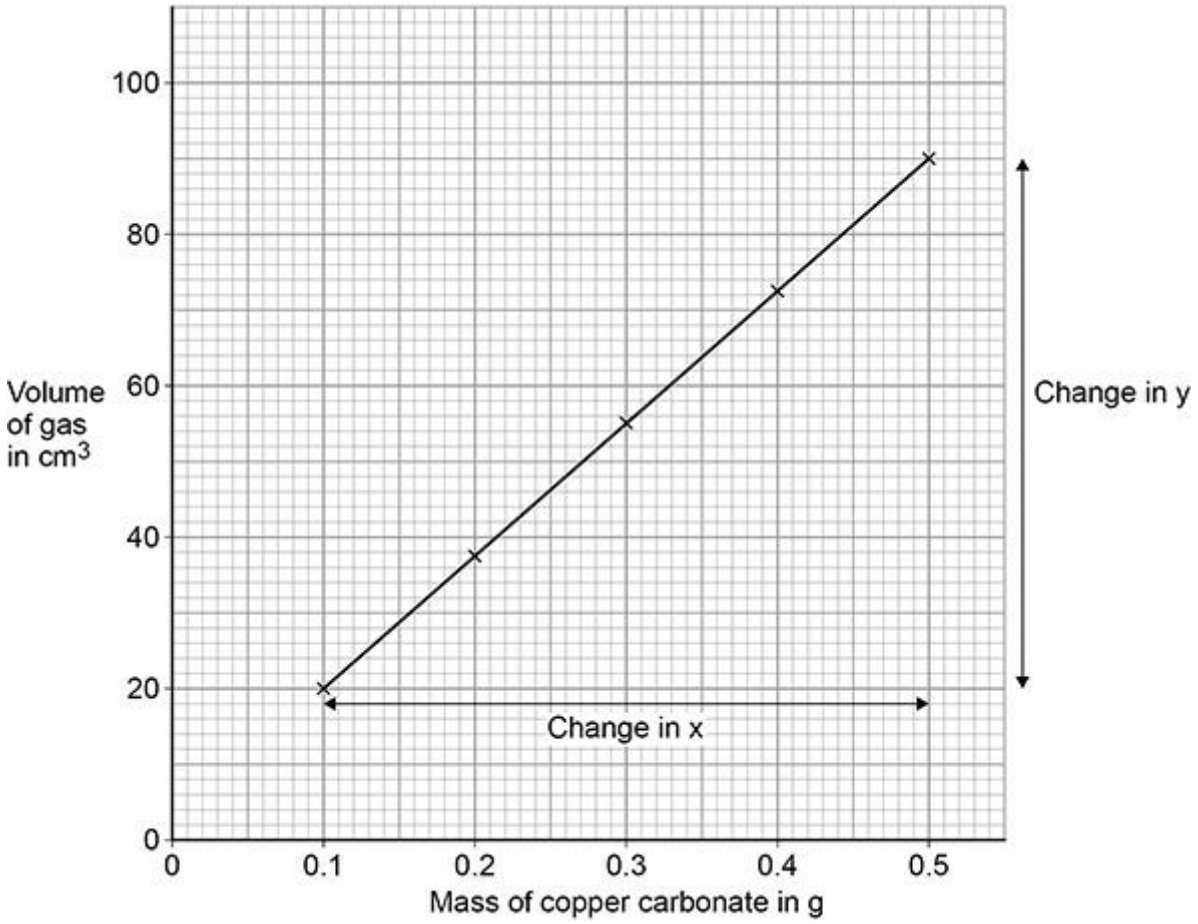
_____ cm^3

(1)

(b) The student plotted the results on a graph.

Figure 3 shows the student's graph.

Figure 3



Determine the gradient of the line of best fit.

You should:

- calculate the values of the change in y and the change in x
- calculate the gradient of the line of best fit.

Change in y =

_____ cm^3

Change in x =
_____ g

Gradient
_____

Gradient = _____ cm^3/g

_____

(4)

(c) Copper chloride was produced in the reaction.

Which acid reacts with copper carbonate to produce copper chloride?

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

(1)

(d) The reaction between copper carbonate and the acid produced a gas.

What was the gas?

Tick (✓) **one** box.

Carbon dioxide ☐

Chlorine ☐

Hydrogen ☐

Oxygen ☐

(1)

A different student produced a pure, dry sample of copper chloride using the same reaction.

This is the method used.

1. Add excess copper carbonate to the acid.

2. Filter the mixture.
3. Heat the solution gently until crystals start to form.
4. Leave for 24 hours.
5. Remove the crystals.
6. Rinse with water and dry the crystals.

(e) Why was the solution heated gently in **step 3**?

Tick (✓) **one** box.

To evaporate acid ☐

To evaporate copper carbonate ☐

To evaporate water ☐

(1)

(f) How should the solution be heated gently in **step 3**?

_____

_____

(1)

(Total 9 marks)

Q3.

This question is about salts.

(a) Name the salt produced by the neutralisation of hydrochloric acid with potassium hydroxide.

_____

(1)

(b) Write an ionic equation for the neutralisation of hydrochloric acid with potassium hydroxide.

_____ + _____ → _____

(1)

(c) Soluble salts can be produced by reacting dilute hydrochloric acid with an insoluble solid.

Copper, copper carbonate and copper oxide are insoluble solids.

Which of these insoluble solids can be used to make a copper salt by reacting the solid with dilute hydrochloric acid?

Tick (✓) **one** box.

Copper and copper carbonate only	☐
Copper and copper oxide only	☐
Copper carbonate and copper oxide only	☐
Copper, copper carbonate and copper oxide	☐

(1)

A student makes crystals of magnesium sulfate.

This is the method used.

1. Add sulfuric acid to a beaker.
2. Warm the sulfuric acid.
3. Add a spatula of magnesium oxide to the beaker.
4. Stir the mixture.
5. Repeat steps 3 and 4 until there is magnesium oxide remaining in the beaker.
6. Filter the mixture.
7. Evaporate the filtrate gently until crystals start to form.
8. Leave the solution to finish crystallising.

(d) Give **one** reason for:

- step 2
- step 5
- step 6.

Step 2 _____

_____

Step 5 _____

_____

Step 6 _____

_____

(3)

(e) How should the filtrate be evaporated gently in **step 7**?

_____

_____

(1)

(f) Iron chloride is produced by heating iron in chlorine gas.

The equation for the reaction is:

$$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$$

Calculate the volume of chlorine needed to react with 14 g of iron.

You should calculate:

- the number of moles of iron used
- the number of moles of chlorine that react with 14 g of iron
- the volume of chlorine needed.

Relative atomic mass (A_r): Fe = 56

The volume of 1 mole of gas = 24 dm^3 **(separate only)**

_____

_____

_____

_____

_____

_____

Volume of chlorine = _____ dm^3

(3)

(Total 10 marks)

Q4.

This question is about acids.

Hydrogen chloride and ethanoic acid both dissolve in water.

All hydrogen chloride molecules ionise in water.

Approximately 1% of ethanoic acid molecules ionise in water.

(a) A solution is made by dissolving 1 g of hydrogen chloride in 1 dm^3 of water.

Which is the correct description of this solution?

Tick (✓) **one** box.

A concentrated solution of a strong acid ☐

A concentrated solution of a weak acid ☐

A dilute solution of a strong acid ☐

A dilute solution of a weak acid ☐

(1)

(b) Which solution would have the lowest pH?

Tick (✓) **one** box.

0.1 mol/dm^3 ethanoic acid solution ☐

0.1 mol/dm^3 hydrogen chloride solution ☐

1.0 mol/dm^3 ethanoic acid solution ☐

1.0 mol/dm^3 hydrogen chloride solution ☐

(1)

A student investigated the concentration of a solution of sodium hydroxide by titration with a 0.0480 mol/dm^3 ethanedioic acid solution.

This is the method used.

1. Measure 25.0 cm^3 of the sodium hydroxide solution into a conical flask using a 25.0 cm^3 pipette.

2. Add two drops of indicator to the sodium hydroxide solution.

3. Fill a burette with the 0.0480 mol/dm^3 ethanedioic acid solution to the 0.00 cm^3 mark.

4. Add the ethanedioic acid solution to the sodium hydroxide solution until the indicator changes colour.

5. Read the burette to find the volume of the ethanedioic acid solution used.

(c) Suggest **two** improvements to the method that would increase the accuracy of the result. **(separate only)**

1 _____

_____

2 _____

_____

(2)

(d) Ethanedioic acid is a solid at room temperature.

Calculate the mass of ethanedioic acid ($H_2C_2O_4$) needed to make 250 cm^3 of a solution with concentration 0.0480 mol/dm^3

Relative formula mass (M_r): $H_2C_2O_4 = 90$ **(separate only)**

_____

_____

_____

_____

Mass = _____g

(2)

(e) The student found that 25.0 cm^3 of the sodium hydroxide solution was neutralised by 15.00 cm^3 of the 0.0480 mol/dm^3 ethanedioic acid solution.

The equation for the reaction is:

$$H_2C_2O_4 + 2\ NaOH \rightarrow Na_2C_2O_4 + 2\ H_2O$$

Calculate the concentration of the sodium hydroxide solution in mol/dm^3

(separate only)

_____

_____

_____

_____

_____

_____

Concentration = _____ mol/dm^3

(3)

(Total 9 marks)

Q5.

This question is about acids, bases and salts.

Zinc nitrate is a salt.

A student produces zinc nitrate using an acid and a base.

(a) Which acid should the student use to produce zinc nitrate?

Tick (✓) **one** box.

Hydrochloric acid ☐

Nitric acid ☐

Sulfuric acid ☐

(1)

(b) Which is a base the student could use to produce zinc nitrate?

Tick (✓) **one** box.

Zinc chloride ☐

Zinc oxide ☐

Zinc sulfate ☐

(1)

(c) Name the salt with the formula $MgBr_2$

_____

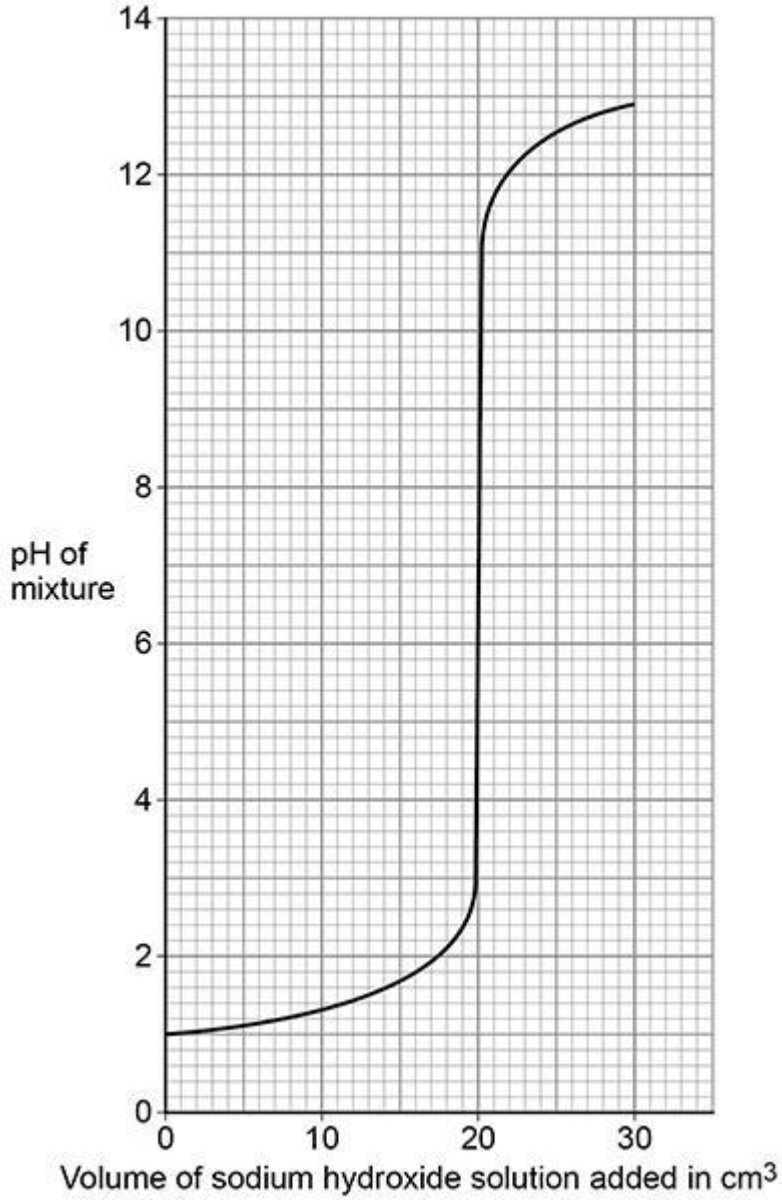
(1)

A student investigated how pH changes during a titration. **(separate only)**

This is the method used.

1. Pour 25.0 cm^3 of hydrochloric acid into a beaker.
2. Measure the pH of the hydrochloric acid with a pH probe.
3. Add 1.0 cm^3 of sodium hydroxide solution from a burette.
4. Swirl the mixture.
5. Measure the pH of the mixture.
6. Repeat steps 3 to 5 until a total of 30.0 cm^3 of sodium hydroxide solution has been added.

The graph below shows the student's results.



(d) Describe how the pH of the mixture changes as sodium hydroxide solution is added to hydrochloric acid.

Use the data from the graph above in your answer. **(separate only)**

(3)

(e) What volume of sodium hydroxide solution is needed to neutralise 25.0 cm^3 of hydrochloric acid?

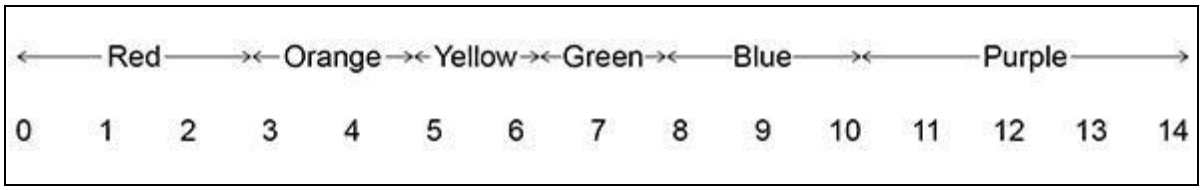
Use the graph above. **(separate only)**

Volume = _____ cm^3

(1)

(f) **Figure 1** shows the colour of universal indicator at different pH values.

Figure 1



The student could have used universal indicator instead of a pH probe.

Determine the colour of universal indicator when 10.0 cm^3 of sodium hydroxide solution has been added to 25.0 cm^3 of hydrochloric acid.

Use the graph above and **Figure 1**. **(separate only)**

Colour = _____

(1)

(g) The student used a pipette to measure 25.0 cm^3 of hydrochloric acid.

Figure 2 shows a pipette.

Figure 2

The pipette is labelled 25.0 ± 0.06 cm^3

Calculate the percentage uncertainty in the volume measured using this pipette. **(separate only)**

Use the equation:

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{volume measured}} \times 100$$

_____

_____

_____

Percentage uncertainty = _____ %

(2)

(h) Give **one** advantage of using a pipette rather than using a measuring cylinder to measure the volume of hydrochloric acid. **(separate only)**

_____

_____

(1)

(Total 11 marks)

Q6.

This question is about acids and alkalis.

(a) Which ion do all acids produce in aqueous solution?

Tick (✓) **one** box.

H^+ ☐

H^- ☐

O^{2-} ☐

OH^- ☐

(1)

(b) Calcium hydroxide solution reacts with an acid to form calcium chloride.

Complete the word equation for the reaction.

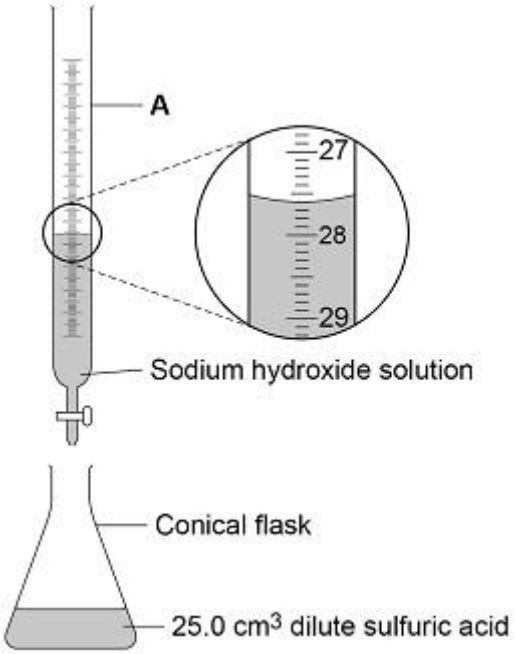
calcium hydroxide + _____ acid → calcium chloride + _____

(2)

A student investigates the volume of sodium hydroxide solution that reacts with 25.0 cm^3 of dilute sulfuric acid.

Figure 1 shows the apparatus the student uses.

Figure 1



Use **Figure 1** to answer parts (c) and (d).

(c) Name apparatus **A**. **(separate only)**

_____

(1)

(d) What is the reading on apparatus **A**? **(separate only)**

_____ cm^3

(1)

(e) The higher the concentration of a sample of dilute sulfuric acid, the greater the volume of sodium hydroxide needed to neutralise the acid.

The student tested two samples of dilute sulfuric acid, **P** and **Q**.

Describe how the student could use titrations to find which sample, **P** or **Q**, is more concentrated. **(separate only)**

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 11 marks)

Q7.

Soluble salts are formed by reacting metal oxides with acids.

(a) Give **one** other type of substance that can react with an acid to form a soluble salt.

(1)

(b) Calcium nitrate contains the ions Ca^{2+} and NO_3^-

Give the formula of calcium nitrate.

(1)

(c) Describe a method to make pure, dry crystals of magnesium sulfate from a metal oxide and a dilute acid.

_____

_____

_____

_____

_____

_____

_____

(6)

(Total 8 marks)

Q8.

This question is about acids and alkalis.

(a) Dilute hydrochloric acid is a strong acid.

Explain why an acid can be described as both strong and dilute.

_____

_____

_____

_____

(2)

(b) A 1.0×10^{-3} mol/dm^3 solution of hydrochloric acid has a pH of 3.0

What is the pH of a 1.0×10^{-5} mol/dm^3 solution of hydrochloric acid?

pH = _____

(1)

A student titrated 25.0 cm^3 portions of dilute sulfuric acid with a 0.105 mol/dm^3 sodium hydroxide solution.

(c) The table below shows the student's results.

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
Volume of sodium hydroxide solution in cm^3	23.50	21.10	22.10	22.15	22.15

The equation for the reaction is:

$$2\ NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2\ H_2O$$

Calculate the concentration of the sulfuric acid in mol/dm^3

Use only the student's concordant results.

Concordant results are those within 0.10 cm^3 of each other. **(separate only)**

Concentration of sulfuric acid = _____ mol/dm^3

(5)

(d) Explain why the student should use a pipette to measure the dilute sulfuric acid and a burette to measure the sodium hydroxide solution. **(separate only)**

(2)

(e) Calculate the mass of sodium hydroxide in 30.0 cm^3 of a 0.105 mol/dm^3 solution.

Relative formula mass (M_r): NaOH = 40

_____

Mass of sodium hydroxide = _____ g

(2)

(Total 12 marks)

Q9.

This question is about metal oxides.

When sodium is heated in oxygen, sodium oxide is produced.

(a) Balance the equation for the reaction.

_____ Na + O_2 → 2 Na_2O

(1)

(b) Why is this an oxidation reaction?

_____

_____

(1)

(c) Sodium oxide is added to water and shaken.
Universal indicator is added.
The pH of the solution is 14

What is the colour of the universal indicator?

Tick (✓) **one** box.

Green ☐

Purple ☐

Red ☐

Yellow ☐

(1)

(d) Aluminium oxide reacts with hydrochloric acid to produce a salt.

What is the name of the salt produced?

Tick (✓) **one** box.

Aluminium chloride ☐

Aluminium nitrate ☐

Aluminium sulfate ☐

Aluminium sulfide ☐

(1)

A student investigates the solubility of four metal oxides and four non-metal oxides in water.

The student tests the pH of the solutions formed.

The table shows the student's results.

Type of oxide	Oxide	Solubility in water	pH of solution
Metal oxides	Sodium oxide	Soluble	14
	Calcium oxide	Soluble	10
	Magnesium oxide	Slightly soluble	9
	Zinc oxide	Insoluble	No solution formed
Non-metal oxides	Carbon dioxide	Soluble	5
	Sulfur dioxide	Soluble	2
	Phosphorus oxide	Soluble	1
	Silicon dioxide	Insoluble	No solution formed

The student makes two conclusions.

Conclusion 1: 'All metal oxides produce alkaline solutions.'

Conclusion 2: 'All non-metal oxides produce acidic solutions.'

(e) Explain why the student's conclusions are only partly correct.

Use information from the table above.

_____

_____

_____

_____

(4)

(f) Give an improved conclusion for metal oxides.

Use the table above.

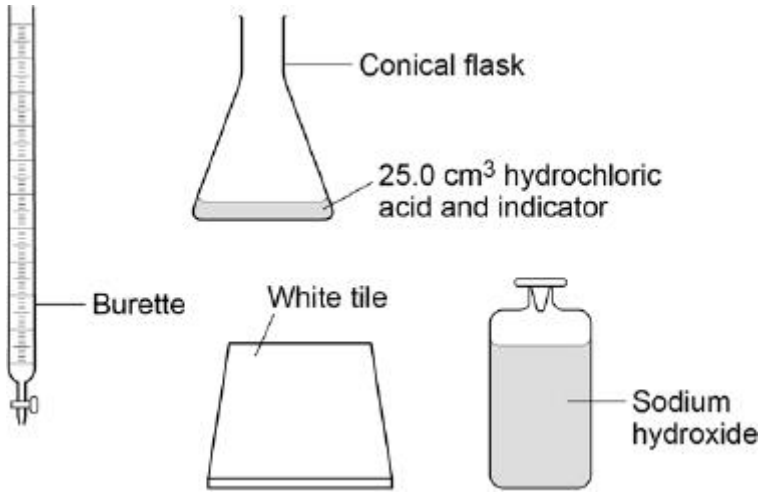
(2)

(Total 9 marks)

Q10. (separate only)

Sodium hydroxide reacts with hydrochloric acid.

The diagram shows apparatus that can be used to find the volume of sodium hydroxide reacting with 25.0 cm^3 hydrochloric acid.



(a) Describe a method to find the exact volume of sodium hydroxide that reacts with 25.0 cm^3 of hydrochloric acid. **(separate only)**

(6)

The reaction produces a solution of sodium chloride.

A student wants to obtain sodium chloride crystals from the sodium chloride solution.

This is the method used.

1. Add solid charcoal to the sodium chloride solution to remove the indicator colour.
2. Remove the solid charcoal.
3. Evaporate the solution to dryness over a Bunsen burner.

(b) Charcoal is not soluble in water.

Suggest a method the student could use to remove the solid charcoal in **Step 2**.

_____

_____

(1)

(c) The student obtains a powdery white solid.

Suggest how the student could improve **Step 3** of the method to obtain larger crystals instead of powder.

_____

_____

(1)

(Total 8 marks)

Q11.

A scientist produces zinc iodide (ZnI_2).

This is the method used.

1. Weigh 0.500 g of iodine.
2. Dissolve the iodine in ethanol.
3. Add an excess of zinc.
4. Stir the mixture until there is no further change.
5. Filter off the excess zinc.
6. Evaporate off the ethanol.

(a) Ethanol is flammable.

Suggest how the scientist could carry out **Step 6** safely.

_____

_____

(1)

(b) Explain why the scientist adds excess zinc rather than excess iodine.

_____

_____

_____

_____

_____

_____

(3)

(c) Calculate the minimum mass of zinc that needs to be added to 0.500 g of iodine so that the iodine fully reacts.

The equation for the reaction is:

$$Zn + I_2 \longrightarrow ZnI_2$$

Relative atomic masses (M_r): Zn = 65 I = 127

_____

_____

_____

_____

_____

_____

Minimum mass of zinc = _____ g

(3)

A different scientist makes zinc iodide by the same method.

The scientist obtains 12.5 g of zinc iodide.

The percentage yield in this reaction is 92.0%.

(d) What is the maximum theoretical mass of zinc iodide produced in this reaction? **(separate only)**

_____

Maximum theoretical mass = _____ g **(3)**

(e) Suggest **one** reason why the percentage yield in this reaction is **not** 100% . **(separate only)**

(1)

(f) The scientist makes a solution of zinc iodide with a concentration of 0.100 mol / dm^3

Calculate the mass of zinc iodide (ZnI_2) required to make 250 cm^3 of this solution.

Relative atomic masses (A_r): Zn = 65 I = 127 **(separate only)**

Mass = _____ g

(3)

(Total 14 marks)

Q12.

Citric acid is a weak acid.

(a) Explain what is meant by a weak acid.

(2)

A student titrated citric acid with sodium hydroxide solution.

This is the method used.

1. Pipette 25.0 cm^3 of sodium hydroxide solution into a conical flask.
2. Add a few drops of thymol blue indicator to the sodium hydroxide solution.
   Thymol blue is blue in alkali and yellow in acid.
3. Add citric acid solution from a burette until the end-point was reached.

(b) Explain what would happen at the end-point of this titration.

Refer to the acid, the alkali and the indicator in your answer. **(separate only)**

(3)

(c) Explain why a pipette is used to measure the sodium hydroxide solution but a burette is used to measure the citric acid solution **(separate only)**

(2)

(d) The table shows the student's results.

	Titration 1	**Titration 2**	**Titration 3**	**Titration 4**	**Titration 5**
Volume of citric acid solution in cm^3	13.50	12.10	11.10	12.15	12.15

The equation for the reaction is:

$$C_6H_8O_7 + 3\,NaOH \longrightarrow C_6H_5O_7Na_3 + 3\,H_2O$$

The concentration of the sodium hydroxide was 0.102 mol / dm^3

Concordant results are those within 0.10 cm^3 of each other.

Calculate the concentration of the citric acid in mol / dm^3
Use only the concordant results from the table in your calculation.
You must show your working. **(separate only)**

_____

_____

_____

_____

_____

_____

_____

Concentration = _____ mol / dm^3

(5)

(Total 12 marks)

Q13.

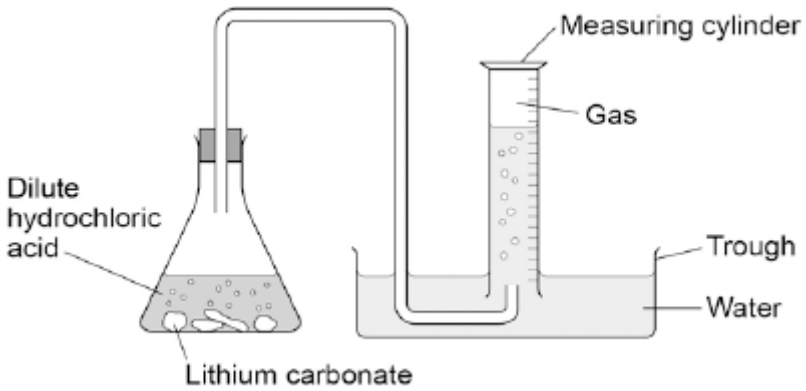
Lithium carbonate reacts with dilute hydrochloric acid.

A group of students investigated the volume of gas produced.

This is the method used.

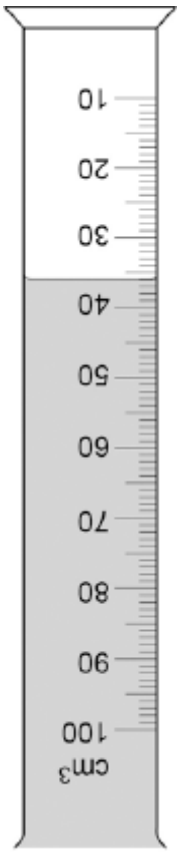
1. Place a known mass of lithium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas as shown in **Figure 1**.

Figure 1



(a) **Figure 2** shows the measuring cylinder.

Figure 2



What volume of gas has been collected?

Volume = _____ cm^3

(1)

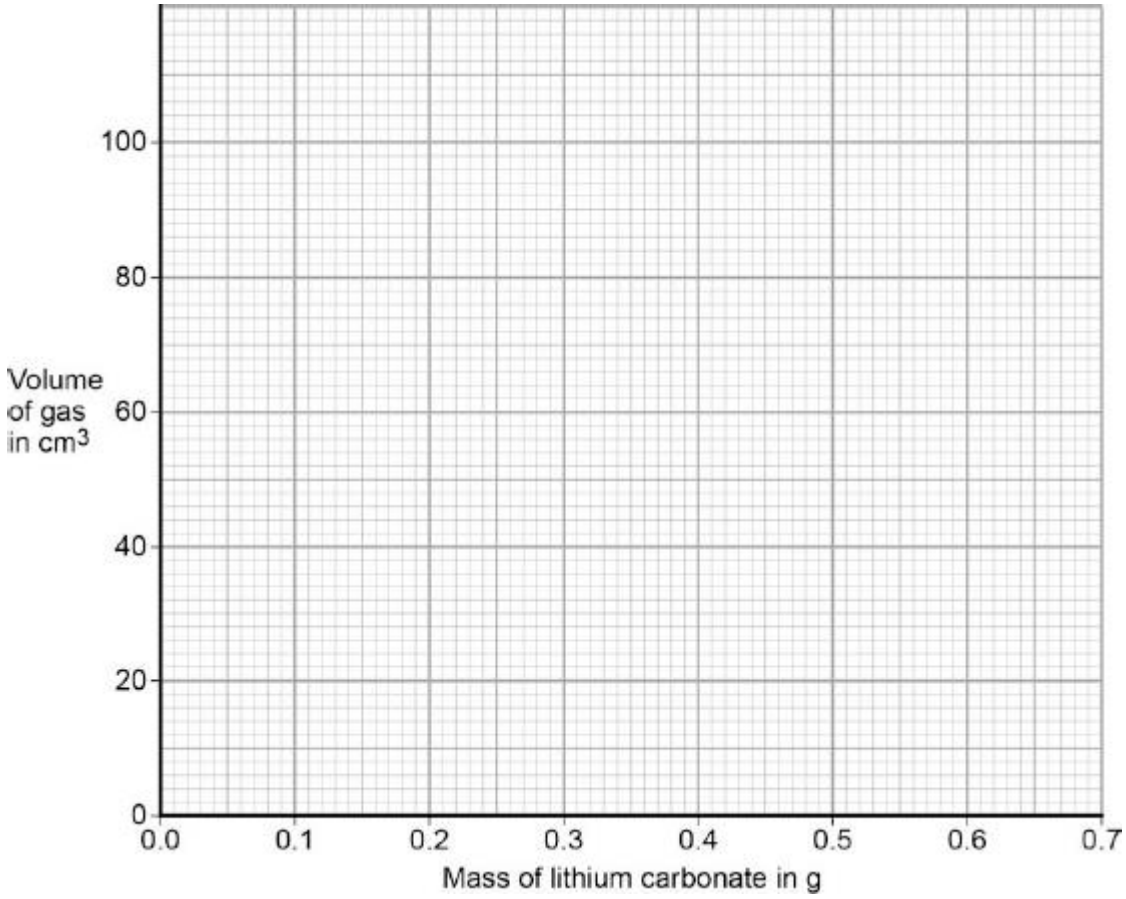
(b) The table below shows the students' results.

Mass of lithium carbonate in g	**Volume of gas in cm^3**
0.0	0
0.1	22
0.2	44
0.3	50
0.4	88
0.5	96
0.6	96
0.7	96

On **Figure 3**:

- Plot these results on the grid.
- Complete the graph by drawing **two** straight lines of best fit.

Figure 3



(4)

(c) What are **two** possible reasons for the anomalous result?

Tick **two** boxes.

- Too much lithium carbonate was added. ☐
- The bung was not pushed in firmly enough. ☐
- There was too much water in the trough. ☐
- The measuring cylinder was not completely over the delivery ☐
- The conical flask was too small. ☐

(2)

(d) Describe the pattern the graph shows up to 0.4 g of lithium carbonate added.

_____

_____

_____

_____

(2)

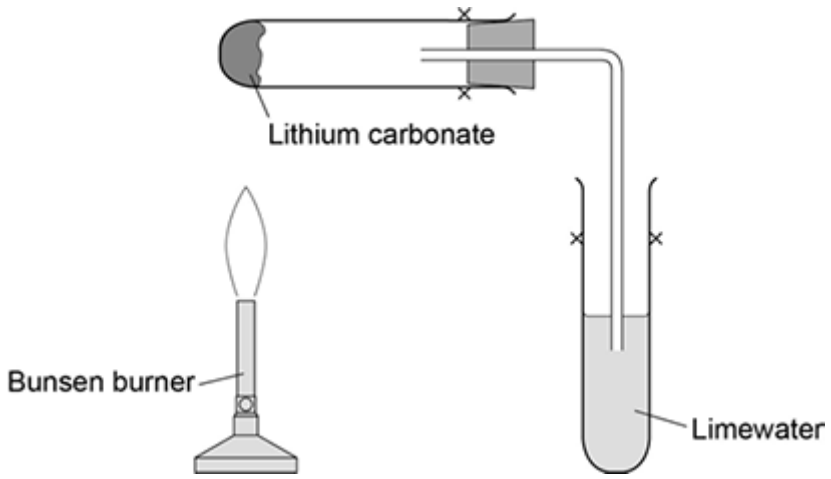
(e) Lithium carbonate decomposes when heated.

The equation shows the decomposition of lithium carbonate.

Li_2CO_3 (s) → Li_2O (s) + CO_2 (g)

Figure 4 shows the apparatus a student used to decompose lithium carbonate.

Figure 4



Why does the limewater bubble?

_____

_____

(1)

(f) The student repeated the experiment with potassium carbonate.
The limewater did not bubble.

Suggest why there were **no** bubbles in the limewater.

_____

_____

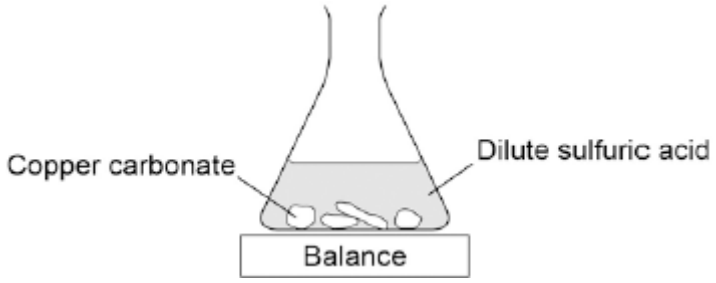
(1)

(Total 11 marks)

Q14.

A student investigated the reaction of copper carbonate with dilute sulfuric acid.

The student used the apparatus shown in the figure below.



(a) Complete the state symbols in the equation.

$CuCO_3$ (___) + H_2SO_4 (aq) → $CuSO_4$ (aq) + H_2O (___) + CO_2 (g)

(2)

(b) Why did the balance reading decrease during the reaction?

Tick **one** box.

The copper carbonate broke down. ☐

A salt was produced in the reaction. ☐

A gas was lost from the flask. ☐

Water was produced in the reaction. ☐

(1)

(c) Describe a safe method for making pure crystals of copper sulfate from copper carbonate and dilute sulfuric acid. Use the information in the figure above to help you.

In your method you should name all of the apparatus you will use.

_____

_____

(6)

(d) The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

The equation for the reaction of copper carbonate and sulfuric acid is:

$$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$$

Relative formula masses : $CuCO_3 = 123.5$; $H_2SO_4 = 98.0$; $CuSO_4 = 159.5$

Calculate the percentage atom economy for making copper sulfate from copper carbonate. **(separate only)**

_____

_____

_____

_____

_____

Atom economy = _____ %

(3)

(e) Give **one** reason why is it important for the percentage atom economy of a reaction to be as high as possible. **(separate only)**

_____

_____

(1)

(Total 13 marks)

Q15.

A student investigated the reactions of copper carbonate and copper oxide with dilute hydrochloric acid.

In both reactions one of the products is copper chloride.

(a) Describe how a sample of copper chloride crystals could be made from copper carbonate and dilute hydrochloric acid.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(b) A student wanted to make 11.0 g of copper chloride.

The equation for the reaction is:

$$CuCO_3 + 2HCl \rightarrow CuCl_2 + H_2O + CO_2$$

Relative atomic masses, A_r: H = 1; C = 12; O = 16; Cl = 35.5; Cu = 63.5

Calculate the mass of copper carbonate the student should react with dilute hydrochloric acid to make 11.0 g of copper chloride.

_____

_____

_____

_____

Mass of copper carbonate = _____ g

(4)

(c) The percentage yield of copper chloride was 79.1 %.

Calculate the mass of copper chloride the student actually produced. **(separate only)**

_____

_____

Actual mass of copper chloride produced = _____ g

(2)

(d) Look at the equations for the two reactions:

Reaction 1 $CuCO_3(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l) + CO_2(g)$

Reaction 2 $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$

Reactive formula masses: CuO = 79.5; HCl = 36.5; $CuCl_2$ = 134.5; H_2O = 18

The percentage atom economy for a reaction is calculated using:

$$\frac{\text{Relative formula mass of desired product from equation}}{\text{Sum of relative formula masses of all reactants from equation}} \times 100$$

Calculate the percentage atom economy for Reaction 2. **(separate only)**

_____

_____

_____

_____

_____

_____

Percentage atom economy = _____ %

(3)

(e) The atom economy for Reaction 1 is 68.45 %.
Compare the atom economies of the two reactions for making copper chloride.

Give a reason for the difference. **(separate only)**

_____

_____

(1)

(Total 14 marks)

Q16.

Sodium carbonate reacts with dilute hydrochloric acid:

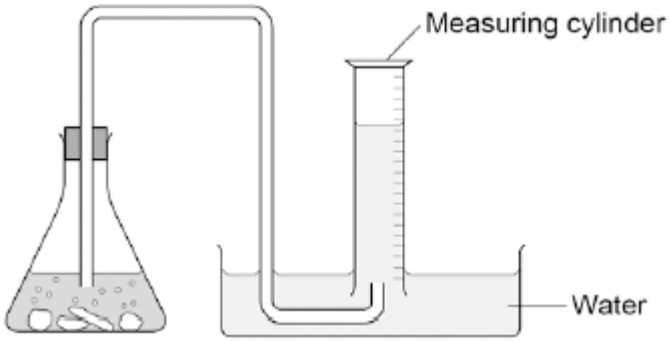
$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

A student investigated the volume of carbon dioxide produced when different masses of sodium carbonate were reacted with dilute hydrochloric acid.

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 10 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas until the reaction is complete.

(a) The student set up the apparatus as shown in the figure below.



Identify the error in the way the student set up the apparatus.

Describe what would happen if the student used the apparatus shown.

_____

_____

_____

_____

(2)

(b) The student corrected the error.

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

Mass of sodium carbonate in g	**Volume of carbon dioxide gas in cm^3**
0.07	16.0
0.12	27.5
0.23	52.0
0.29	12.5
0.34	77.0
0.54	95.0
0.59	95.0
0.65	95.0

The result for 0.29 g of sodium carbonate is anomalous.

Suggest what may have happened to cause this anomalous result.

_____

_____

(1)

(c) Why does the volume of carbon dioxide collected stop increasing at 95.0 cm^3?

_____

_____

(1)

(d) What further work could the student do to be more certain about the minimum mass of sodium carbonate needed to produce 95.0 cm^3 of carbon dioxide?

_____

_____

(1)

(e) The carbon dioxide was collected at room temperature and pressure. The volume of one mole of any gas at room temperature and pressure is 24.0 dm^3.

How many moles of carbon dioxide is 95.0 cm^3?

Give your answer in three significant figures. **(separate only)**

_____

_____

_____

_____

_____ mol

(2)

(f) Suggest **one** improvement that could be made to the apparatus used that would give more accurate results.

Give a reason for your answer.

_____

_____

_____

_____

(2)

(g) One student said that the results of the experiment were wrong because the first few bubbles of gas collected were air.

A second student said this would make no difference to the results.

Explain why the second student was correct.

_____

_____

_____

_____

_____

_____

(2)

(Total 11 marks)

Q17.

Sodium hydroxide neutralises sulfuric acid.

The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(a) Sulfuric acid is a strong acid.

What is meant by a strong acid?

_____

_____

_____

(2)

(b) Write the ionic equation for this neutralisation reaction. Include state symbols.

_____

(2)

(c) A student used a pipette to add 25.0 cm^3 of sodium hydroxide of unknown concentration to a conical flask.

The student carried out a titration to find out the volume of 0.100 mol / dm^3 sulfuric acid needed to neutralise the sodium hydroxide.

Describe how the student would complete the titration.

You should name a suitable indicator and give the colour change that would be seen. **(separate only)**

_____

_____

(4)

(d) The student carried out five titrations. Her results are shown in the table below.

	Titration 1	Titration 2	Titration 3	Titration 4	Titration 5
Volume of 0.100 mol / dm^3 sulfuric acid in cm^3	27.40	28.15	27.05	27.15	27.15

Concordant results are within 0.10 cm^3 of each other.

Use the student's concordant results to work out the mean volume of 0.100 mol / dm^3 sulfuric acid added. **(separate only)**

Mean volume = _____ cm^3

(2)

(e) The equation for the reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration of the sodium hydroxide.

Give your answer to three significant figures. **(separate only)**

Concentration = _____ mol / dm^3

(4)

(f) The student did another experiment using 20 cm^3 of sodium hydroxide solution with a concentration of 0.18 mol / dm^3.

Relative formula mass (M_r) of NaOH = 40

Calculate the mass of sodium hydroxide in 20 cm^3 of this solution. **(separate only)**

Mass = _____ g

(2)

(Total 16 marks)

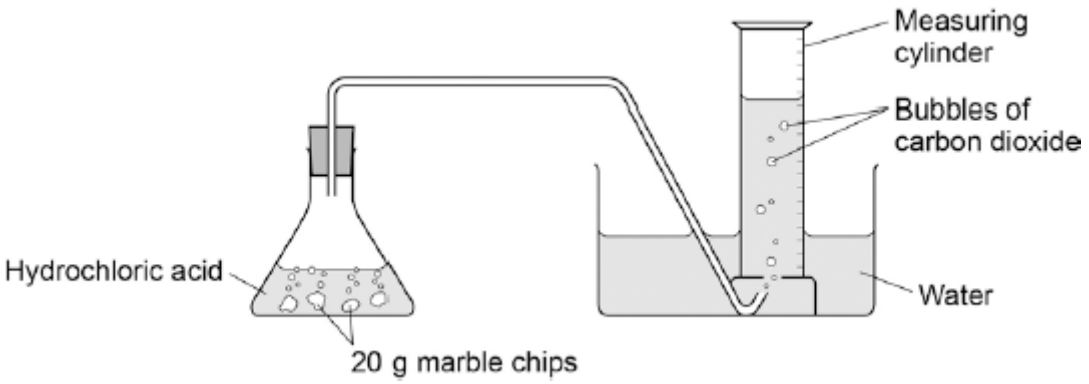
Q18.

Marble chips are mainly calcium carbonate ($CaCO_3$).

A student investigated the rate of reaction between marble chips and hydrochloric acid (HCl).

Figure 1 shows the apparatus the student used.

Figure 1



(a) Complete and balance the equation for the reaction between marble chips and hydrochloric acid.

_____ + _____ → $CaCl_2$ + _____ + _____

(2)

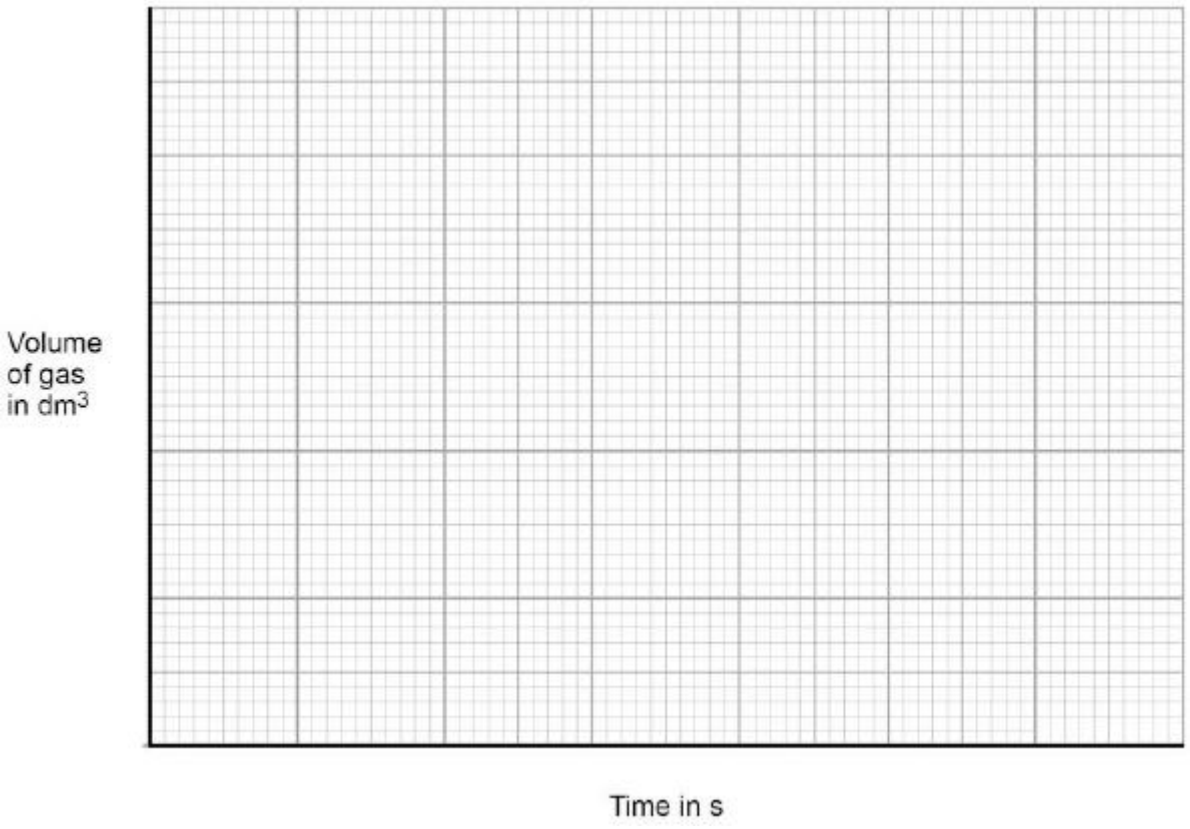
(b) The table below shows the student's results.

Time in s	**Volume of gas in dm^3**
0	0.000
30	0.030
60	0.046
90	0.052
120	0.065
150	0.070
180	0.076
210	0.079
240	0.080
270	0.080

On **Figure 2**:

- Plot these results on the grid.
- Draw a line of best fit.

Figure 2



(4)

(c) Sketch a line on the grid in **Figure 2** to show the results you would expect if the experiment was repeated using 20 g of smaller marble chips.

Label this line **A**.

(2)

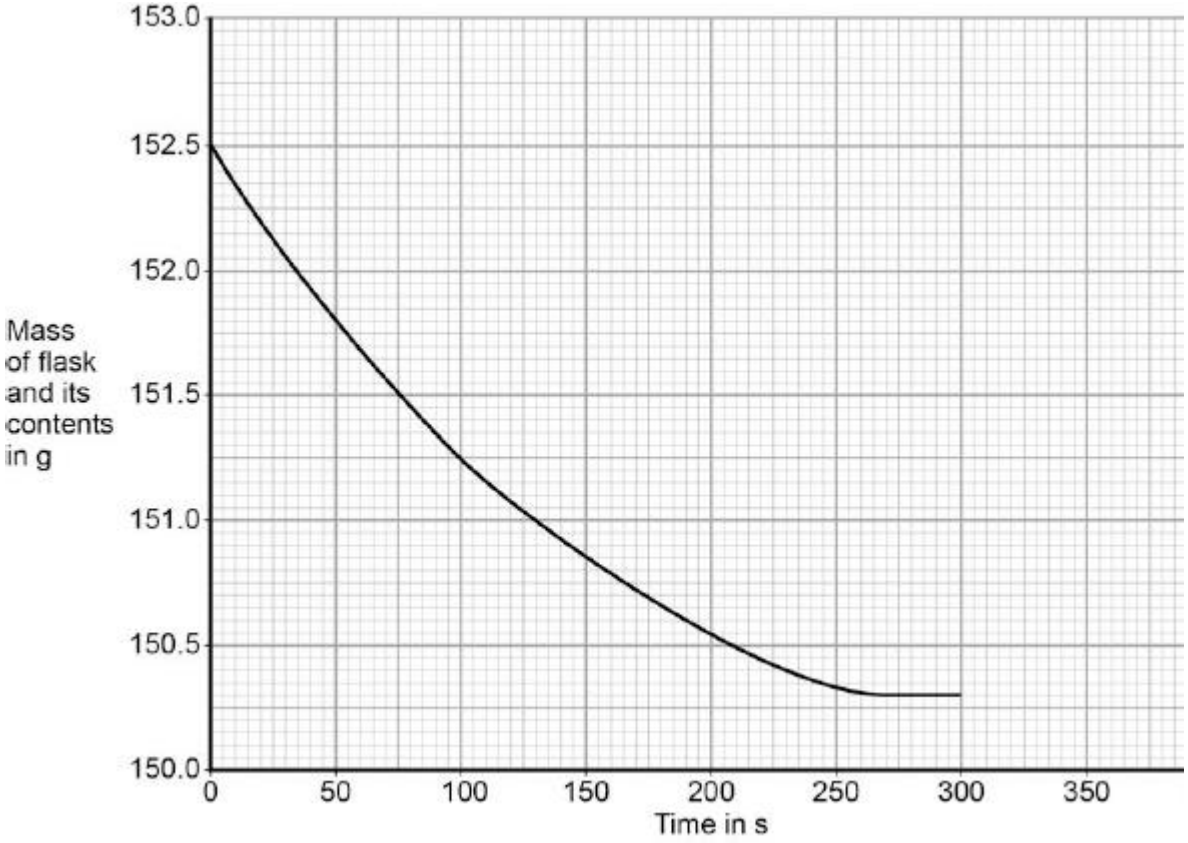
(d) Explain, in terms of particles, how and why the rate of reaction changes during the reaction of calcium carbonate with hydrochloric acid.

(4)

(e) Another student investigated the rate of reaction by measuring the change in mass.

Figure 3 shows the graph plotted from this student's results.

Figure 3



Use **Figure 3** to calculate the mean rate of the reaction up to the time the reaction is complete.

Give your answer to three significant figures.

Mean rate of reaction = _____ g / s

(4)

(f) Use **Figure 3** to determine the rate of reaction at 150 seconds.

Show your working on **Figure 3**.

Give your answer in standard form.

_____

_____

_____

_____

_____

Rate of reaction at 150 s = _____ g / s

(4)

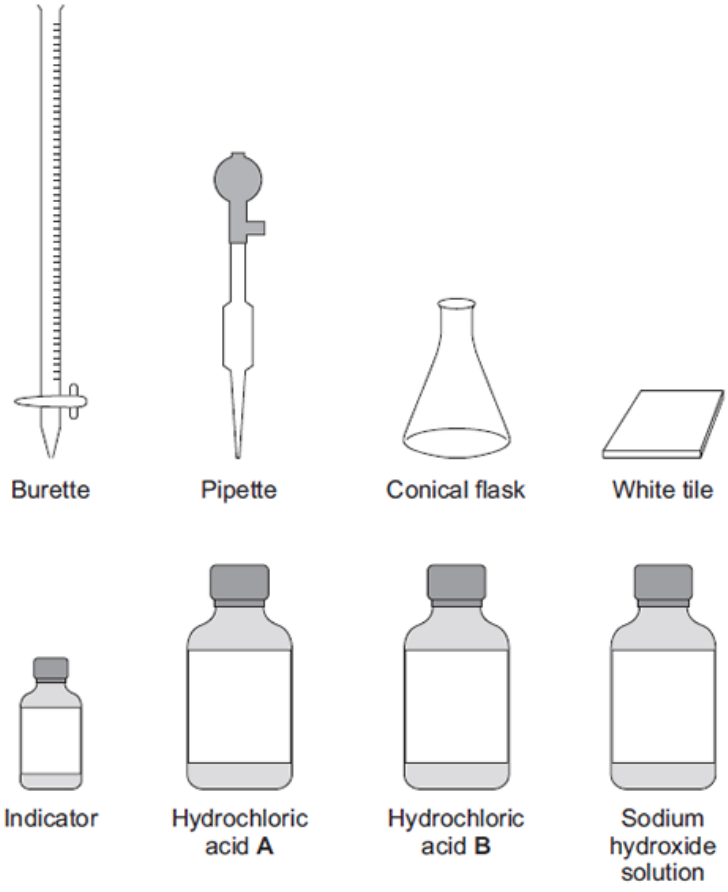
(Total 20 marks)

Q19. (separate only)

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

A student has to check if two samples of hydrochloric acid, **A** and **B**, are the same concentration.

Describe how the student could use the apparatus and the solutions in the diagram below to carry out titrations. **(separate only)**



(Total 6 marks)