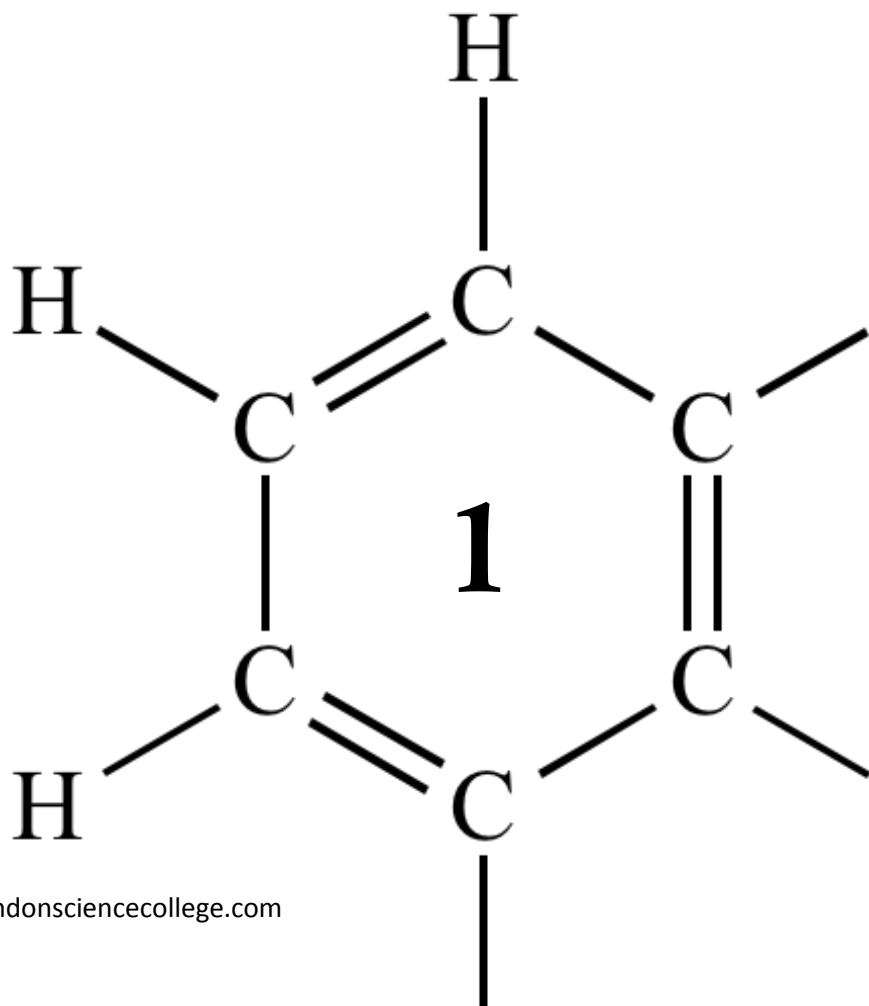


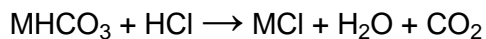
AQA AS CHEMISTRY

AMOUNT OF SUBSTANCE



1

This question is about a white solid, MHCO_3 , that dissolves in water and reacts with hydrochloric acid to give a salt.



A student was asked to design an experiment to determine a value for the M_r of MHCO_3 . The student dissolved 1464 mg of MHCO_3 in water and made the solution up to 250 cm^3 . 25.0 cm^3 samples of the solution were titrated with $0.102 \text{ mol dm}^{-3}$ hydrochloric acid. The results are shown in the table.

	Rough	1	2	3
Initial burette reading / cm^3	0.00	10.00	19.50	29.25
Final burette reading / cm^3	10.00	19.50	29.25	38.90
Titre / cm^3	10.00	9.50	9.75	9.65

- (a) Calculate the mean titre and use this to determine the amount, in moles, of HCl that reacted with 25.0 cm^3 of the MHCO_3 solution.

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(3)

- (b) Calculate the amount, in moles, of MHCO_3 in 250 cm^3 of the solution. Then calculate the experimental value for the M_r of MHCO_3 . Give your answer to the appropriate number of significant figures.

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(3)

- (c) The student identified use of the burette as the largest source of uncertainty in the experiment.

Using the same apparatus, suggest how the procedure could be improved to reduce the percentage uncertainty in using the burette.

Justify your suggested improvement.

Suggestion

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Justification

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(2)

- (d) Another student is required to make up 250 cm³ of an aqueous solution that contains a known mass of MHCO₃. The student is provided with a sample bottle containing the MHCO₃.

Describe the method, including apparatus and practical details, that the student should use to prepare the solution.

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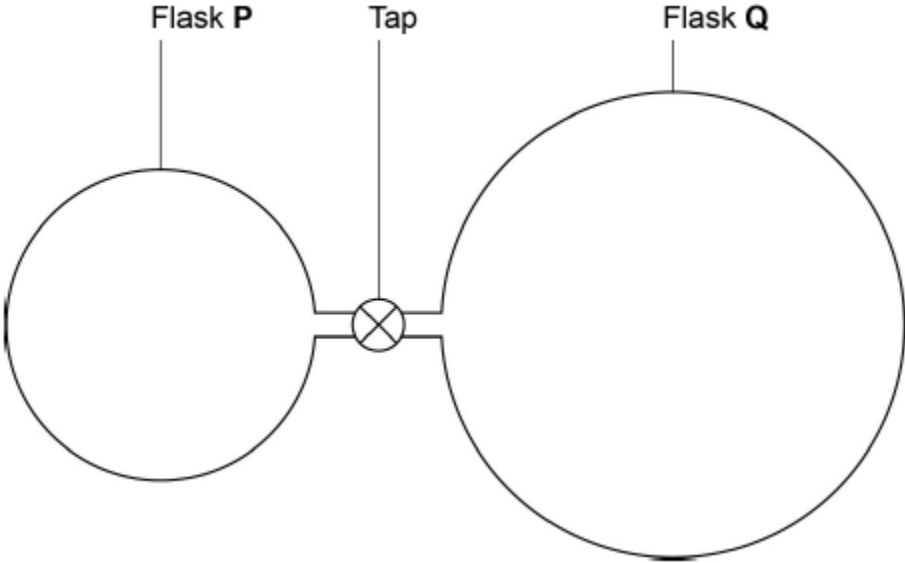
(6)
(Total 14 marks)

2

The diagram represents two glass flasks, **P** and **Q**, connected via a tap.

Flask **Q** (volume = $1.00 \times 10^3 \text{ cm}^3$) is filled with ammonia (NH_3) at 102 kPa and 300 K. The tap is closed and there is a vacuum in flask **P**.

(Gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$)



- (a) Calculate the mass of ammonia in flask **Q**.
Give your answer to the appropriate number of significant figures.

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(3)

- (b) When the tap is opened, ammonia passes into flask **P**. The temperature decreases by $5 \text{ }^\circ\text{C}$. The final pressure in both flasks is 75.0 kPa.
Calculate the volume, in cm^3 , of flask **P**.

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(3)

(Total 6 marks)

3

A student was given a powder made from a mixture of anhydrous barium chloride and anhydrous magnesium chloride. The student dissolved 1.056 g of the powder in water in a conical flask and added an excess of sulfuric acid.

A white precipitate formed and was filtered off, washed and dried.

The mass of this solid was 0.764 g.

Identify the white precipitate and calculate the percentage, by mass, of magnesium chloride in the powder.

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(Total 4 marks)

4

There are 392 mol of pure gold in a bar measuring 10 cm by 10 cm by 40 cm.

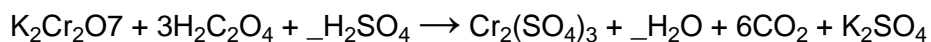
What is the density of gold in kg dm^{-3} ?

- A 193
- B 19.3
- C 1.93
- D 0.193

(Total 1 mark)

5

Refer to the unbalanced equation below when answering this question.



In the balanced equation the mole ratio for sulfuric acid to water is

A 1 : 4**B** 1 : 2**C** 4 : 7**D** 4 : 9

(Total 1 mark)

6

In a molecule of a hydrocarbon, the fraction by mass of carbon is $\frac{9}{11}$

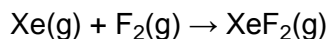
What is the empirical formula of the hydrocarbon?

A CH**B** CH₃**C** C₃H₈**D** C₅H₁₂

(Total 1 mark)

7

30 cm³ of xenon are mixed with 20 cm³ of fluorine. The gases react according to the following equation. Assume that the temperature and pressure remain constant.



What is the final volume of gas after the reaction is complete?

A 50 cm³**B** 40 cm³**C** 30 cm³**D** 20 cm³

(Total 1 mark)

8

Which of the following solutions would react exactly with a solution containing 0.0500 mol sulfuric acid?

A 50.0 cm³ of 1.00 mol dm⁻³ KOH

B 100.0 cm³ of 2.00 mol dm⁻³ KOH

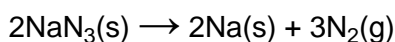
C 100.0 cm³ of 2.00 mol dm⁻³ Ba(OH)₂

D 50.0 cm³ of 1.00 mol dm⁻³ Ba(OH)₂

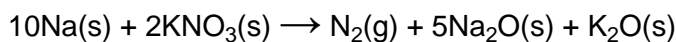
(Total 1 mark)

9

In a car airbag, sodium azide (NaN₃) decomposes to form sodium metal and nitrogen gas.



The sodium metal then reacts with potassium nitrate to produce more nitrogen gas.



If 2.00 mol of sodium azide react in this way, how many molecules of N₂ will be formed?
(The Avogadro constant L = 6.022 × 10²³ mol⁻¹)

A 2.41 × 10²⁴

B 1.93 × 10²⁴

C 1.81 × 10²⁴

D 9.63 × 10²³

(Total 1 mark)

10

Refrigerants are substances used to cool refrigerators and freezers. Until recently, many of the compounds used as refrigerants were chlorofluorocarbons (CFCs), but these are now known to form chlorine radicals. CFCs have been phased out in many countries by international agreement.

(a) Write **two** equations to show how chlorine radicals react with ozone molecules in the upper atmosphere.

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2

(2)

(b) Chloropentafluoroethane is a CFC that has been used as a refrigerant.

Draw its displayed formula.

(1)

(c) 1,1,1-trifluoroethane (CF_3CH_3) is one of the molecules that has been used as a refrigerant in place of CFCs.

Explain why 1,1,1-trifluoroethane does not lead to the depletion of the ozone in the upper atmosphere.

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(1)

(d) One of the steps in the synthesis of 1,1,1-trifluoroethane (CF_3CH_3) is the reaction of 1,1-difluoroethane (CHF_2CH_3) with fluorine in a free-radical substitution reaction.

Write **two** equations to represent the propagation steps in this conversion of CHF_2CH_3 into CF_3CH_3

Propagation step 1

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Propagation step 2

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(2)

- (e) A refrigerator contains 1.41 kg of 1,1,1-trifluoroethane (CF_3CH_3).

Calculate the number of molecules of 1,1,1-trifluoroethane in the refrigerator.

Give your answer to an appropriate number of significant figures.

(The Avogadro constant $L = 6.022 \times 10^{23} \text{ mol}^{-1}$)

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(2)

- (f) There are growing concerns about the use of 1,1,1-trifluoroethane as a refrigerant as it is a greenhouse gas that absorbs some of Earth's infrared radiation.

Give **one** reason why bonds in molecules such as carbon dioxide and 1,1,1-trifluoroethane absorb infrared radiation.

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(1)

(Total 9 marks)

11

When an aqueous solution of ethanoic acid reacts with magnesium, the progress of reaction can be followed using the equipment shown in **Figure 1** to measure the volume of hydrogen produced.

Figure 1

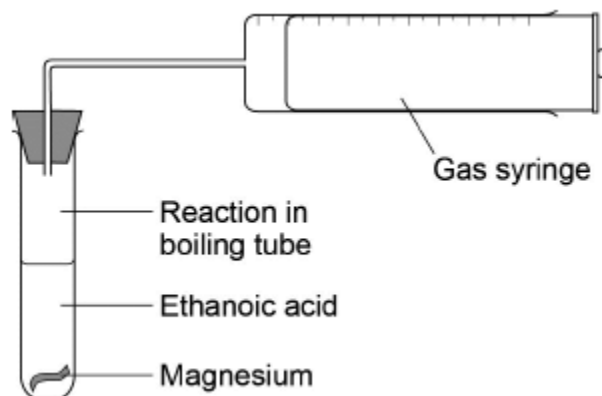
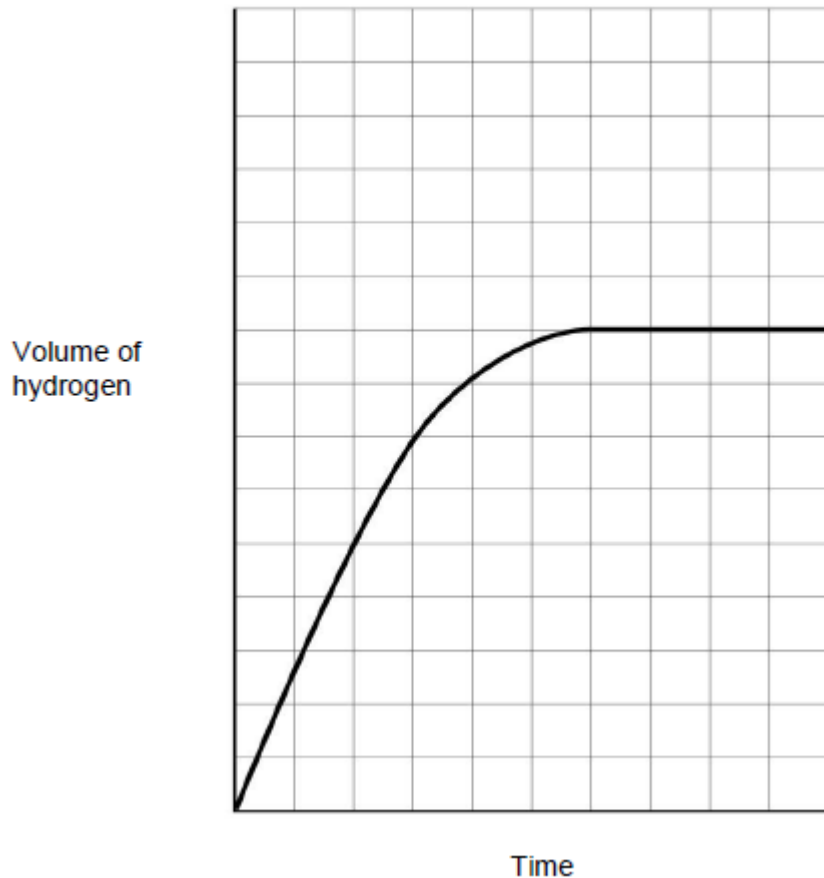
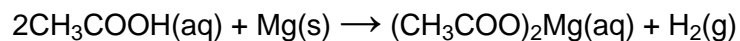


Figure 2 shows how the volume of hydrogen produced varies with time when 396 mg of magnesium are added to 30.0 cm³ of 0.600 mol dm⁻³ ethanoic acid.

Figure 2



(a) The equation for the reaction between ethanoic acid and magnesium is shown.



With the aid of calculations, show that the magnesium is in excess in this reaction.

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(3)

- (b) The reaction was repeated using 20 cm^3 of $0.800 \text{ mol dm}^{-3}$ of ethanoic acid solution with all other conditions the same. The magnesium was still in excess.

Sketch a line on **Figure 2** to show how the volume of hydrogen produced varies with time in this second experiment.

Space for working.

(2)
(Total 5 marks)

12

Propene can be made by the dehydration of propan-2-ol.

What is the percentage yield when 30 g of propene ($M_r = 42.0$) are formed from 50 g of propan-2-ol ($M_r = 60.0$)?

- A 60%
- B 67%
- C 81%
- D 86%

(Total 1 mark)

13

An organic compound is found to contain 40.0% carbon, 6.7% hydrogen and 53.3% oxygen.

Which of the following compounds could this be?

A Ethanol

B Ethanoic acid

C Methanol

D Methanoic acid

(Total 1 mark)

14

The M_r of hydrated copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) is 249.6.

Which of the following is the mass of hydrated copper sulfate required to make 50.0 cm^3 of a $0.400 \text{ mol dm}^{-3}$ solution?

A 3.19 g

B 3.55 g

C 3.71 g

D 4.99 g

(Total 1 mark)

15

2 mol of ideal gas **X** are stored in a flask of fixed volume.

Which of the following changes would lead to the greatest increase in pressure inside the flask?

A Increasing the temperature from $20 \text{ }^\circ\text{C}$ to $200 \text{ }^\circ\text{C}$

B Adding another 1 mol of gas **X** into the flask at fixed temperature

C Adding 0.5 mol of argon gas and increasing the temperature from $20 \text{ }^\circ\text{C}$ to $150 \text{ }^\circ\text{C}$

D Removing 0.5 mol of gas **X** and increasing the temperature from $20 \text{ }^\circ\text{C}$ to $300 \text{ }^\circ\text{C}$

(Total 1 mark)

16

Compounds containing Cu^{2+} , OH^- and CO_3^{2-} ions are sometimes described as basic copper carbonates.

(a) Solid $\text{Cu}_2(\text{OH})_2\text{CO}_3$ is added to an excess of dilute hydrochloric acid. A solution of copper(II) chloride is formed, together with two other products.

(i) Write an equation for the reaction.

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(2)

(ii) Suggest **one** observation that could be made during the reaction.

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(1)

(b) A 5.000 g sample of a different basic copper carbonate contains 0.348 g of carbon, 0.029 g of hydrogen and 1.858 g of oxygen.

(i) State what is meant by the term empirical formula.

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(1)

(ii) Calculate the empirical formula of this basic copper carbonate. Show your working.

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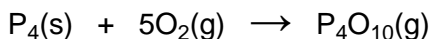
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(3)
(Total 7 marks)

17

Phosphoric(V) acid (H_3PO_4) is an important chemical. It can be made by two methods. The first method is a two-step process.

- (a) In the first step of the first method, phosphorus is burned in air at $500\text{ }^\circ\text{C}$ to produce gaseous phosphorus(V) oxide.



220 g of phosphorus were reacted with an excess of air.

Calculate the volume, in m^3 , of gaseous phosphorus(V) oxide produced at a pressure of 101 kPa and a temperature of $500\text{ }^\circ\text{C}$.

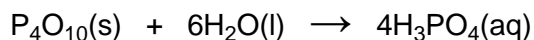
The gas constant $R = 8.31\text{ J K}^{-1}\text{ mol}^{-1}$

Give your answer to 3 significant figures.

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(4)

- (b) In the second step of the first method, phosphorus(V) oxide reacts with water to form phosphoric(V) acid.

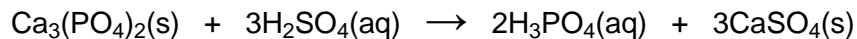


Calculate the mass of phosphorus(V) oxide required to produce 3.00 m^3 of 5.00 mol dm^{-3} phosphoric(V) acid solution.

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(3)

- (c) In the second method to produce phosphoric(V) acid, 3.50 kg of $\text{Ca}_3(\text{PO}_4)_2$ are added to an excess of aqueous sulfuric acid.



1.09 kg of phosphoric(V) acid are produced.

Calculate the percentage yield of phosphoric(V) acid.

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(4)

- (d) Explain whether the first method or the second method of production of phosphoric acid has the higher atom economy.
You are not required to do a calculation.

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(1)

(Total 12 marks)

18

This question is about the elements in Group 2 and their compounds.

- (a) Use the Periodic Table to deduce the full electron configuration of calcium.

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(1)

- (b) Write an ionic equation, with state symbols, to show the reaction of calcium with an excess of water.

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(1)

- (c) State the role of water in the reaction with calcium.

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(1)

- (d) Write an equation to show the process that occurs when the first ionisation energy of calcium is measured.

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(1)

- (e) State and explain the trend in the first ionisation energies of the elements in Group 2 from magnesium to barium.

Trend

Explanation

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(3)

(Total 7 marks)

19

- (a) Write an equation, including state symbols, for the reaction with enthalpy change equal to the standard enthalpy of formation for $\text{CF}_4(\text{g})$.

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(1)

- (b) Explain why CF_4 has a bond angle of 109.5° .

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(2)

(c) **Table 1** gives some values of standard enthalpies of formation ($\Delta_f H^\ominus$).

Table 1

Substance	F ₂ (g)	CF ₄ (g)	HF(g)
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	0	-680	-269

The enthalpy change for the following reaction is $-2889 \text{ kJ mol}^{-1}$.

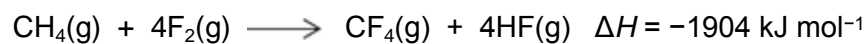


Use this value and the standard enthalpies of formation in **Table 1** to calculate the standard enthalpy of formation of C₂H₆(g).

Standard enthalpy of formation of C₂H₆(g) = kJ mol⁻¹

(3)

(d) Methane reacts violently with fluorine according to the following equation.



Some mean bond enthalpies are given in **Table 2**.

Table 2

Bond	C-H	C-F	H-F
Mean bond enthalpy / kJ mol^{-1}	412	484	562

A student suggested that one reason for the high reactivity of fluorine is a weak F-F bond.

Is the student correct? Justify your answer with a calculation using these data.

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(4)
(Total 10 marks)

20

This question is about reactions of calcium compounds.

- (a) A pure solid is thought to be calcium hydroxide. The solid can be identified from its relative formula mass.

The relative formula mass can be determined experimentally by reacting a measured mass of the pure solid with an excess of hydrochloric acid. The equation for this reaction is



The unreacted acid can then be determined by titration with a standard sodium hydroxide solution.

You are provided with 50.0 cm³ of 0.200 mol dm⁻³ hydrochloric acid.

Outline, giving brief practical details, how you would conduct an experiment to calculate accurately the relative formula mass of the solid using this method.

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(8)

- (b) A 3.56 g sample of calcium chloride was dissolved in water and reacted with an excess of sulfuric acid to form a precipitate of calcium sulfate.

The percentage yield of calcium sulfate was 83.4%.

Calculate the mass of calcium sulfate formed.

Give your answer to an appropriate number of significant figures.

Mass of calcium sulfate formed = g

(3)
(Total 11 marks)