OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



EXAM QUESTION PACK

C5.1 MONITORING CHEMICAL REACTIONS

SCORE	PERCENTAGE
/193	%

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Gateway Chemistry A (9-1)

Monitoring chemical reactions

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:
Additional resources may be supplied with this paper.

Other materials required:
- Pencil
- Ruler (cm/mm)

Duration: Not set

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **193**.
- The total number of marks may take into account some 'either/or' question choices.

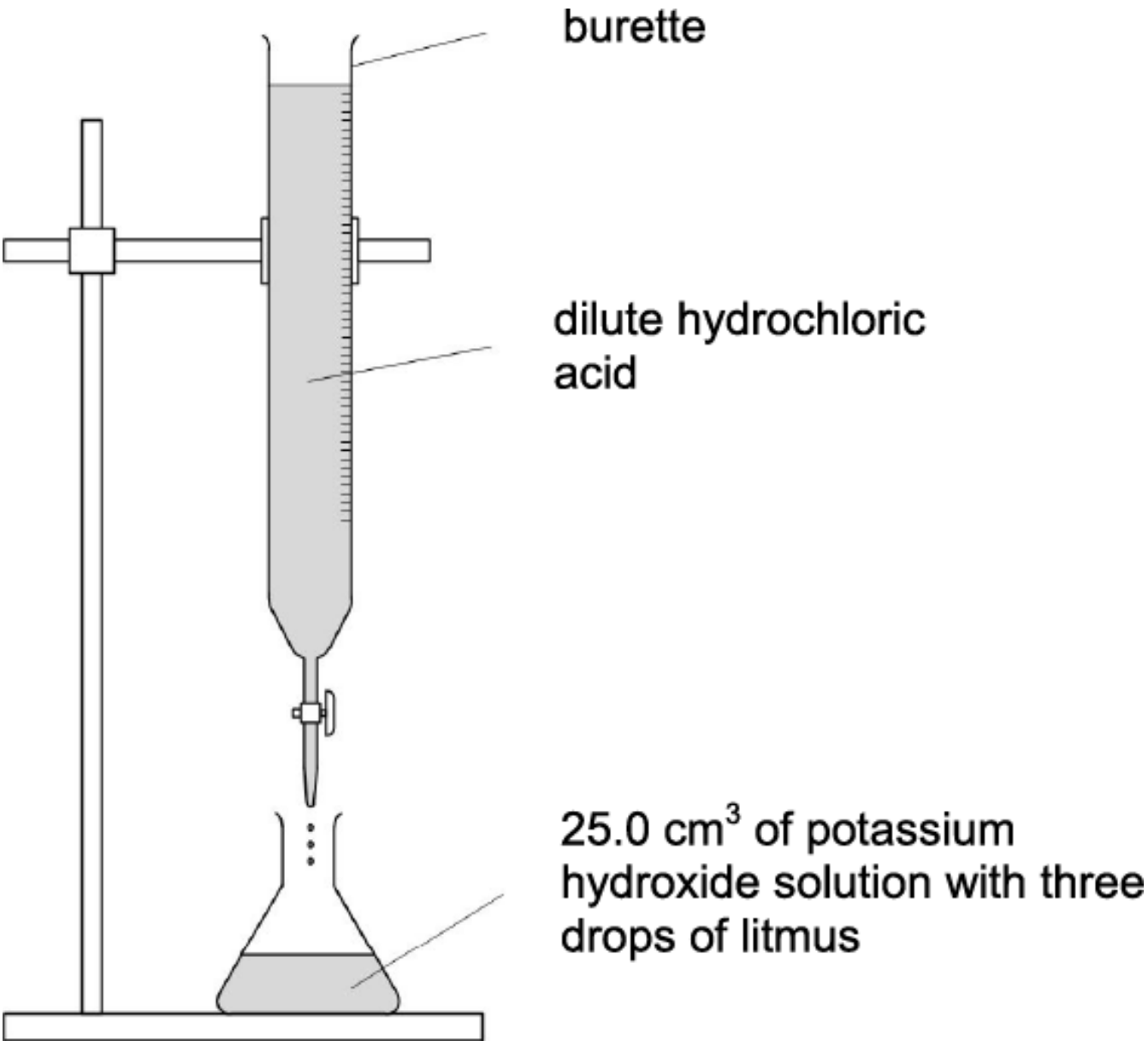
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1 Sarah does three titrations with dilute hydrochloric acid and potassium hydroxide solution.

Look at the apparatus she uses.



In her first titration Sarah measures the initial volume of hydrochloric acid in the burette.

She slowly adds the acid until the potassium hydroxide is just neutralised.

She then measures the volume of the hydrochloric acid again.

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Describe how Sarah can tell when the potassium hydroxide solution is just neutralised.

[2]

2 Urea is a fertiliser.

The formula for urea is

$(NH_2)_2CO$

A student makes 1 mole of urea from 2 moles of ammonia.

What is the mass of urea that the student makes?

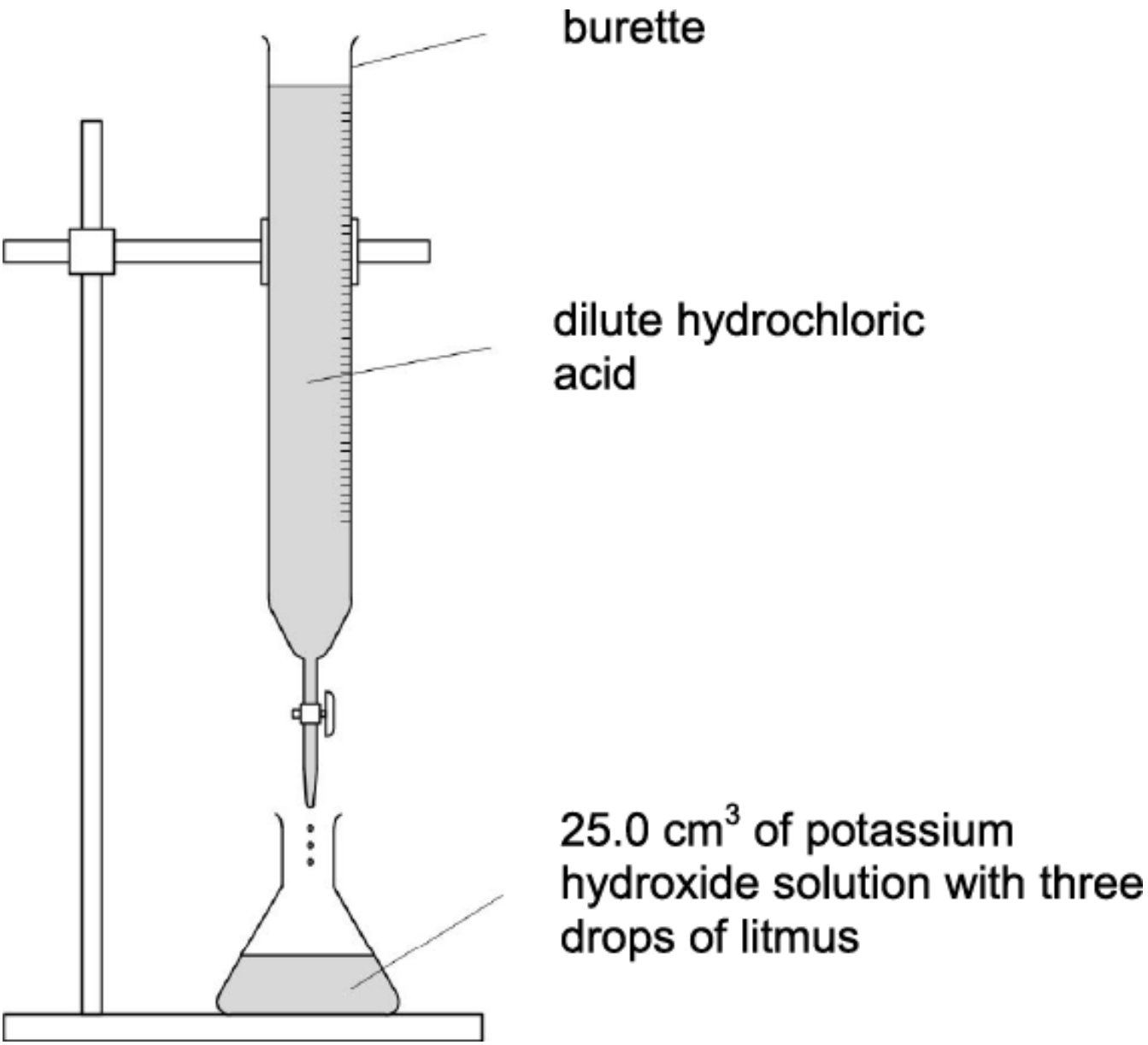
A 43.0 g
B 44.0 g
C 58.0 g
D 60.0 g

Your answer ☐

[1]

3(a) Sarah does three titrations with dilute hydrochloric acid and potassium hydroxide solution.

Look at the apparatus she uses.

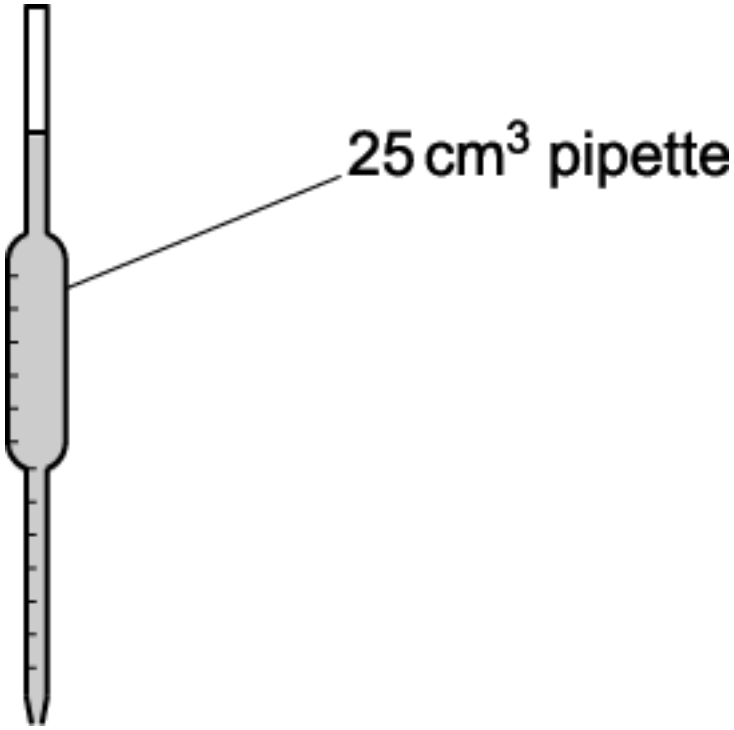


Sarah uses a pipette to measure out the 25.0 cm^3 of potassium hydroxide solution.

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Describe and explain one safety precaution Sarah uses with the pipette.

--- [2]

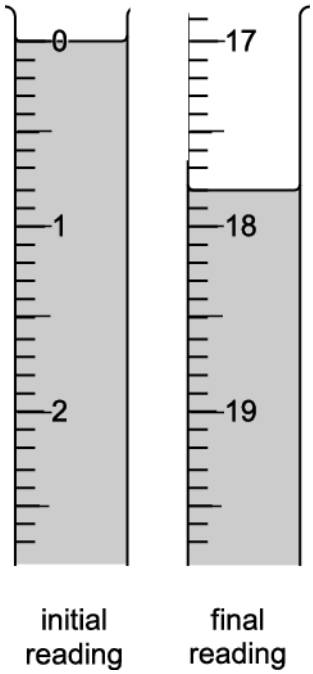
(b) Look at the diagrams. They show parts of the burette during the first titration.

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first titration



Here is Sarah's results table.

Titration number	1	2	3
final reading in cm^3		37.5	32.1
initial reading in cm^3		20.4	15.0
titre (volume of acid added) in cm^3		17.1	17.1

(i) **Complete** the table by reading the burette readings from the diagrams.

[2]

(ii) Sarah thinks the mean titre is 17.1 cm^3.

Is she correct?

Explain your answer.

---

[1]

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(c) Sarah does a titration to make a fertiliser called potassium nitrate, KNO_3.

Look at the equation for the reaction she uses.

$$KOH + HNO_3 \rightarrow KNO_3 + H_2O$$

The relative formula masses, M_r, of each compound are shown in the table.

compound	formula	relative formula mass
potassium hydroxide	KOH	56.1
nitric acid	HNO_3	63.0
potassium nitrate	KNO_3	101.1
water	H_2O	18.0

What is the atom economy for the reaction to make potassium nitrate?

Assume that water is a waste product.

Atom economy = _____ % **[2]**

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4 The reversible reaction between carbon dioxide and hydrogen makes methane and water.

$$\text{carbon dioxide} + \text{hydrogen} \rightleftharpoons \text{methane} + \text{water}$$

Kayvan investigates this reaction.

He predicts that 11.0 g of carbon dioxide should make 4.0 g of methane.

In an experiment, he finds that 11.0 g of carbon dioxide makes 2.2 g of methane.

Calculate the percentage yield of methane.

Percentage yield = _____ % **[2]**

5 Ammonium sulfate is a salt.

It is manufactured using the reaction between the alkali ammonia and sulfuric acid.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

A sample containing 17.0 g of ammonia completely reacts with sulfuric acid.

A mass of 66.0 g of ammonium sulfate is made.

Show that the maximum mass of ammonium sulfate that can be made from 51.0 g of ammonia is 198.0 g.

[1]

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6 Urea is a fertiliser.

The formula for urea is:

$(NH_2)_2CO$

A student makes 1 mole of urea from 2 moles of ammonia.

What is the mass of urea that the student makes?

A 43.0 g
B 44.0 g
C 58.0 g
D 60.0 g

Your answer ☐

[1]

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7 A student is making a fertiliser called potassium nitrate, KNO_3.

Look at the equation for the reaction she uses.

$$KOH + HNO_3 \rightarrow KNO_3 + H_2O$$

The relative formula masses, M_r, of each compound are shown in the table.

Compound	Formula	Relative formula mass
potassium hydroxide	KOH	56.1
nitric acid	HNO_3	63.0
potassium nitrate	KNO_3	101.1
water	H_2O	18.0

What is the atom economy for the reaction to make potassium nitrate?

Assume that water is a waste product.

A 15.1%
B 47.1%
C 52.9%
D 84.9%

Your answer ☐

[1]

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8 Zinc nitrate thermally decomposes to give two gases.

$$2Zn(NO_3)_2(s) \rightarrow 2ZnO(s) + 4NO_2(g) + O_2(g)$$

A student heats 1.89 g of zinc nitrate until there is no further reaction.

What is the total volume of gas, measured at room temperature and pressure, made in this reaction?

Assume that one mole of gas occupies a volume of 24 dm^3 at room temperature and pressure.

The molar mass of zinc nitrate is 189 g/mol.

A 0.12 dm^3
B 0.48 dm^3
C 0.60 dm^3
D 1.20 dm^3

Your answer ☐

[1]

9 Which of the following procedures is the most suitable for preparing a 0.100 mol/dm^3 solution of sodium carbonate?

The relative formula mass, M_r, of sodium carbonate is 106.

A Dissolving 10.6 g of sodium carbonate in water to make 1.0 dm^3 of solution.
B Dissolving 10.6 g of sodium carbonate in 0.10 dm^3 of water.
C Dissolving 10.6 g of sodium carbonate in 1.0 dm^3 of water.
D Dissolving 106 g of sodium carbonate in water to make 1.0 dm^3 of solution.

Your answer ☐

[1]

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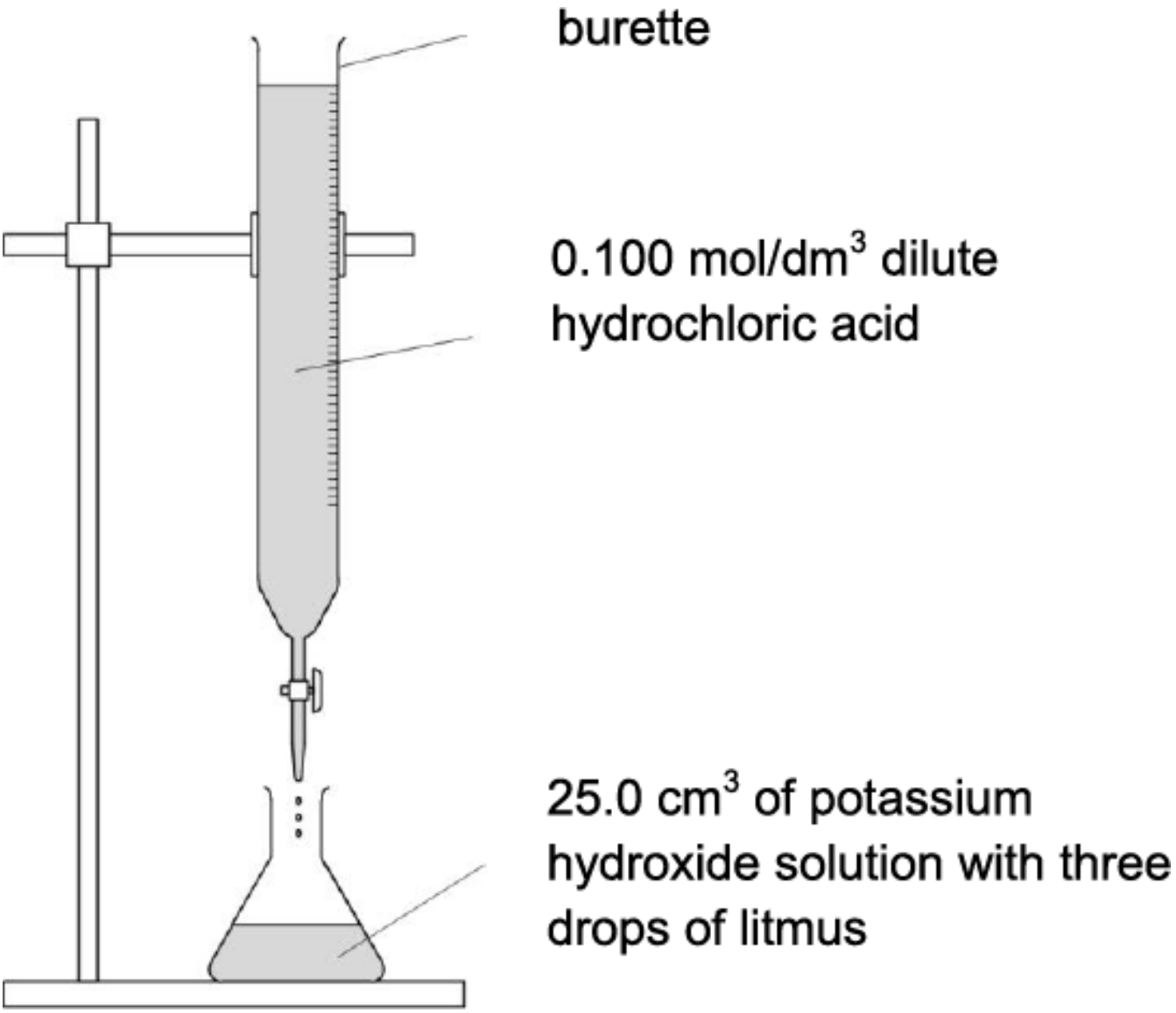
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10(a) Sarah does three titrations with dilute hydrochloric acid and potassium hydroxide solution.

Hydrochloric acid neutralises the alkali potassium hydroxide.

$$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$$

Look at the apparatus she uses.



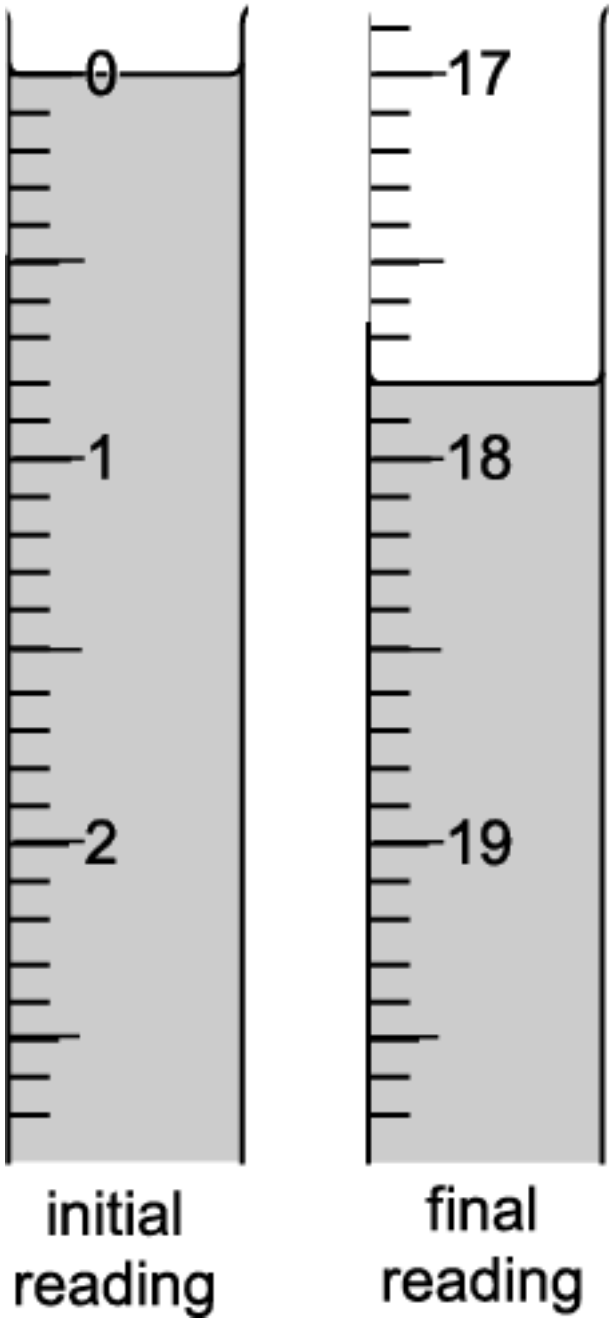
Look at the diagrams. They show parts of the burette during the first titration.

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First titration



Here is Sarah's results table:

Titration number	1	2	3
final reading (cm^3)		37.5	32.1

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initial reading (cm^3)		20.4	15.0
titre (volume of acid added) (cm_3)		17.1	17.1

Use the diagrams and table to help you calculate the mean titre.

Explain your answer.

Mean titre = _____ cm^3 **[2]**

(b) Sarah uses 25.0 cm^3 of potassium hydroxide solution, KOH.

She also uses hydrochloric acid with a concentration of 0.100 mol/dm^3.

Calculate the concentration, in mol/dm^3, of the KOH(aq).

Concentration of KOH(aq) = _____ mol/dm^3 **[2]**

(c) Use your answer to **(b)** to calculate the concentration of the KOH(aq) in g/dm^3.

Concentration of KOH(aq) = _____ g/dm^3 **[2]**

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11 The reversible reaction between carbon dioxide and hydrogen makes methane and water.

$$\text{carbon dioxide} + \text{hydrogen} \rightleftharpoons \text{methane} + \text{water}$$

Kayvan investigates this reaction.

He predicts that 11.0 g of carbon dioxide should make 4.0 g of methane.

In an experiment, he finds that 11.0 g of carbon dioxide makes 2.2 g of methane.

Calculate the percentage yield of methane.

Percentage yield = _____ % **[2]**

12 Ammonium sulfate is a salt.

It is made using the reaction between the alkali ammonia and sulfuric acid.

$$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$

(i) Describe how a sample of solid ammonium sulfate is prepared in a laboratory.

Explain why this method is not suitable to be used industrially.

---

[4]

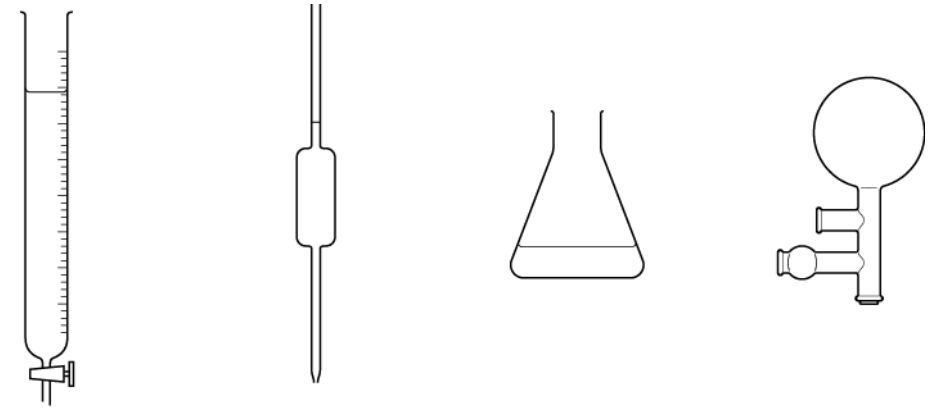
(ii) Predict the maximum mass of ammonium sulfate that can be made from 51 tonnes of ammonia.

Maximum mass = _____ tonnes [2]

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13 Stewart and Claire want to do a titration.

Look at the diagrams. They show some of the apparatus they use.



They want to titrate dilute hydrochloric acid with dilute sodium hydroxide solution.

Describe, in detail, how they do the titration. Include any safety precautions they should take.

You may wish to draw a labelled diagram to help your answer.

The quality of written communication will be assessed in your answer to this question.

[6]

14(a) Stowmarket Synthetics manufacture ethanoic acid, $C_2H_4O_2$, by two different processes.

Process **1** $C_2H_6O + O_2 \rightarrow C_2H_4O_2 + H_2O$

Process **2** $CH_4O + CO \rightarrow C_2H_4O_2$

Look at the table of relative formula masses.

Compound	Formula	Relative formula mass, M_r
ethanol	C_2H_6O	46
oxygen	O_2	32
ethanoic acid	$C_2H_4O_2$	60
water	H_2O	18
methanol	CH_4O	32
carbon monoxide	CO	28

The relative atomic mass of H = 1, of C = 12, and of O = 16.

In process **2**, Stowmarket Synthetics use 320 g of methanol.

Calculate the maximum mass of ethanoic acid that can be made.

---

[2]

(b) Stowmarket Synthetics know that the **atom economy** of a process is important.

Water is a waste product in process **1**.

Show that the atom economy for making ethanoic acid by process **1** is 77%.

---

[2]

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(c) Stowmarket Synthetics also know that the **percentage yield** of a process is important.

The factory uses 5.2 tonnes of methanol in process **2**.

A scientist predicts they should make 9.8 tonnes of ethanoic acid.

They actually make 9.5 tonnes of ethanoic acid.

Show that the percentage yield of ethanoic acid is 97%.

---

[2]

(d) Look at the table.

It gives information about the atom economy and percentage yield for making ethanoic acid.

Process	Atom economy (%)	Percentage yield (%)
1	77	85
2	100	97

Process **2** has a higher atom economy and a higher percentage yield.

(i) Explain one advantage, other than cost, of a very high atom economy.

---

[1]

(ii) Explain one advantage, other than cost, of a very high percentage yield.

---

[1]

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15(a) Stowmarket Synthetics manufacture ethanoic acid, $C_2H_4O_2$, by two different processes.

Process **1** $C_2H_6O + O_2$? $C_2H_4O_2 + H_2O$

Process **2** CH_4O + ? CO $C_2H_4O_2$

Look at the table of relative formula masses.

Compound	Formula	Relative formula mass, *Mr*
ethanol	C_2H_6O	
oxygen	O_2	32
ethanoic acid	$C_2H_4O_2$	60
water	H_2O	18
methanol	CH_4O	32
carbon monoxide	CO	28

The relative atomic mass of H = 1, of C = 12, and of O = 16.

Calculate the relative formula mass of ethanol, C_2H_6O.

---

relative formula mass = _____

[1]

(b) In process **2** Stowmarket Synthetics use 320 g of methanol.

They make 600 g of ethanoic acid.

What mass of carbon monoxide do they need?

---

mass of carbon monoxide = _____ g

[1]

(c) Stowmarket Synthetics know that the **atom economy** of a process is important.

Water is a waste product in process **1**.

Show that the atom economy for making ethanoic acid by process **1** is 77%.

---

[2]

(d) Stowmarket Synthetics also know that the **percentage yield** of a process is important.

The factory uses 5.2 tonnes of methanol in process **2**.

A scientist predicts they should make 9.8 tonnes of ethanoic acid.

They actually make 9.5 tonnes of ethanoic acid.

Show that the percentage yield of ethanoic acid is 97%.

---

[2]

(e) Look at the table.

It gives information about the atom economy and percentage yield for making ethanoic acid.

Process	Atom economy (%)	Percentage yield (%)
1	77	85
2	100	97

Process **2** is a 'greener' process than process **1**.

Explain why.

---

[1]

16 It is necessary to dilute a concentrated solution in medicines and in some food preparation.

Write about **one** example of the need for dilution in medicine and **one** example in food preparation.

In each example explain why it is important to dilute the solution.

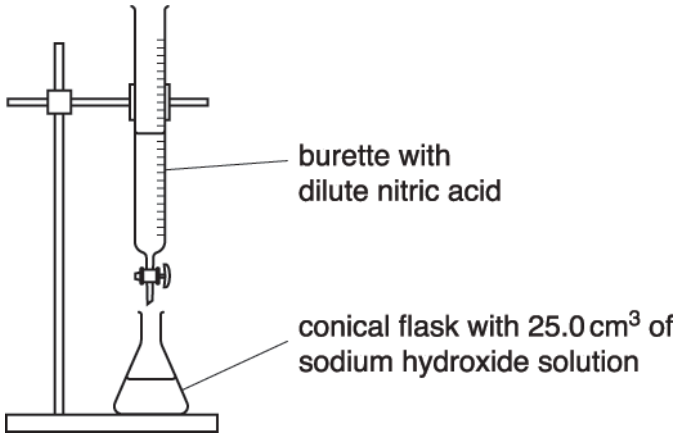
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[2]

17(a) Sam does some titrations.

She uses sodium hydroxide solution and dilute nitric acid.

Look at the apparatus she uses.



Sam adds five drops of litmus indicator to the conical flask.

She records the burette reading at the start and slowly adds the acid to the flask.

She records the burette reading at the end-point of the titration.

Describe the colour change of the litmus at the end-point of the titration.

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[2]

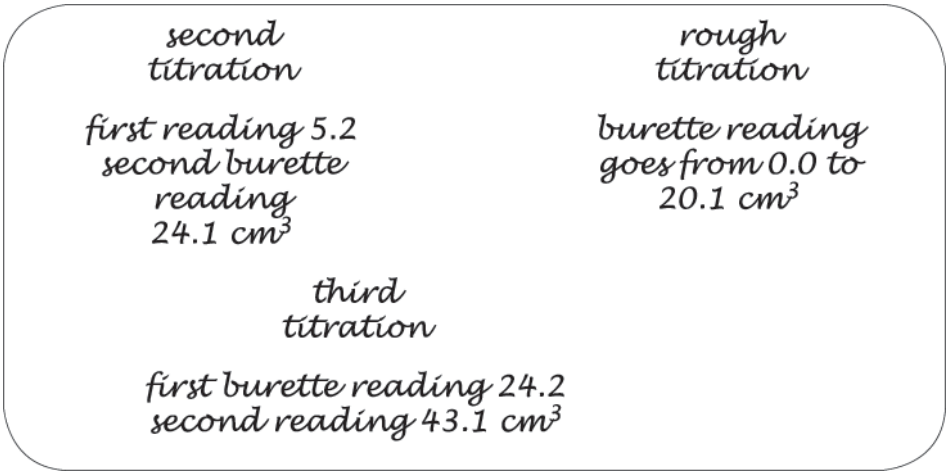
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(b) Sam does three titrations.

Look at a page from her exercise book. It shows her results.



(i) Present Sam's results in a table.

Include in the table the titres (the volume of acid added).

[2]

(ii) Which titrations should Sam use to work out the average (mean) titre?

What is the average (mean) titre for these titrations?

Give your answer to one decimal place.

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Average (mean) titre = _____ cm^3

[2]

18(a) This question is about acids.

Nitric acid, HNO_3, is a strong acid and propanoic acid, C_2H_5COOH, is a weak acid.

David investigates the reaction of both of these acids with calcium carbonate.

David does two experiments

- the first with nitric acid
- the second with propanoic acid.

Each time he puts 50 cm^3 of 2.0 mol/dm^3 acid into a conical flask.

He then adds the same mass of calcium carbonate to each acid.

David measures the total volume of carbon dioxide made every 10 seconds.

Draw a labelled diagram of the apparatus David can use in these experiments.

[2]

(b) Look at the balanced symbol equation for the reaction of calcium carbonate with nitric acid.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$$

(i) David's experiment with nitric acid makes 60 cm^3 of carbon dioxide at room temperature and pressure.

How many moles of carbon dioxide are made at the end of the reaction?

One mole of carbon dioxide has a volume of 24 000 cm^3 at room temperature and pressure.

moles of carbon dioxide = _____

[1]

(ii) Calculate the mass of calcium carbonate needed to make this amount of carbon dioxide.

The relative formula mass, M_r, of calcium carbonate, $CaCO_3$, is 100.

mass of calcium carbonate = _____ g

[1]

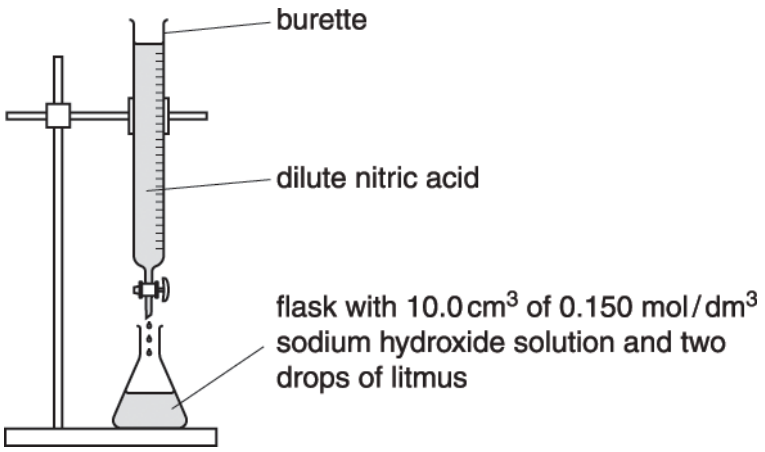
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19(a) Cristina titrates dilute nitric acid with sodium hydroxide solution.

Look at the diagram of her apparatus.



Cristina slowly adds dilute nitric acid into the flask until the end point is reached.

Cristina does three more titrations.

Look at her results table.

Titration number	1	2	3	4
Final burette reading in cm^3	26.5	49.2	26.4	40.3
Initial burette reading in cm^3	0.0	24.1	1.2	15.0
Titre (volume of acid added) in cm^3	26.5	25.1	25.2	25.3

(i) Cristina calculates the mean titre to be 25.2 cm^3.

Explain why this is the **best** mean value from these results.

---

[2]

(ii) Cristina uses 10.0 cm^3 of sodium hydroxide solution.

The concentration of the sodium hydroxide solution is 0.150 mol / dm^3.

Calculate the number of moles of sodium hydroxide in 10.0 cm^3 of this solution.

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---

number of moles = _____

[1]

(iii) Look at the equation for the reaction between nitric acid and sodium hydroxide.

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

Use the information from parts **(i)** and **(ii)** to calculate the concentration of the nitric acid.

Give your answer to **three** significant figures.

---

concentration of nitric acid = _____ mol / dm^3

[2]

(b) Cristina uses litmus to tell her when the end point is reached.

She **should not** use universal indicator.

Explain why.

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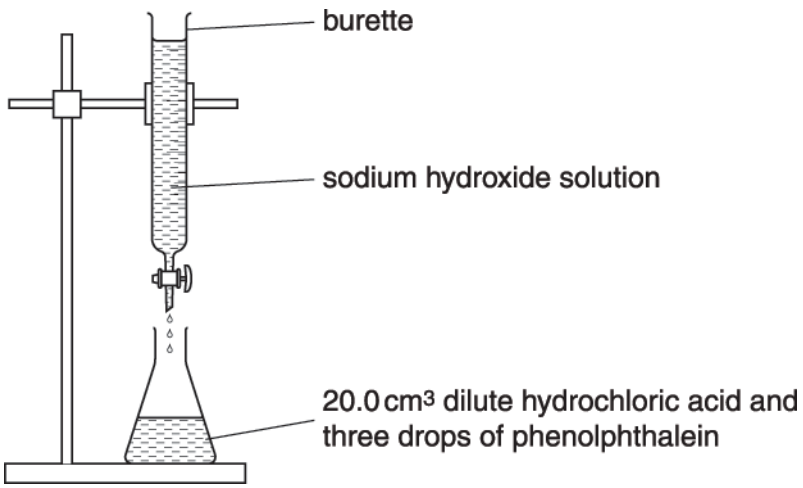
[1]

20(a) This question is about acid-base titrations.

Brian neutralises dilute hydrochloric acid with sodium hydroxide solution.

He wants to find out the concentration of the sodium hydroxide solution.

Look at the apparatus.



Brian adds sodium hydroxide solution slowly until the phenolphthalein changes colour. He does the titration four times.

Look at Brian's results.

Titration number	1	2	3	4
Volume of sodium hydroxide added in cm^3	25.9	24.9	25.1	25.0

Brian calculates the mean volume of sodium hydroxide solution to be 25.0 cm^3.

Titration 1 was not included in the calculation of the mean volume of sodium hydroxide added.

Suggest why.

---------- [1]

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(b) Look at the equation for the reaction.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

The mean volume of sodium hydroxide solution used is 25.0 cm^3.

Brian uses 20.0 cm^3 of hydrochloric acid.

The concentration of the hydrochloric acid is 0.100 mol / dm^3.

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

answer _____ mol / dm^3

[3]

(c) Brian adds sodium hydroxide solution slowly until the phenolphthalein changes colour.

Phenolphthalein is a single indicator.

Universal indicator is a mixed indicator.

Explain why Brian used phenolphthalein rather than universal indicator.

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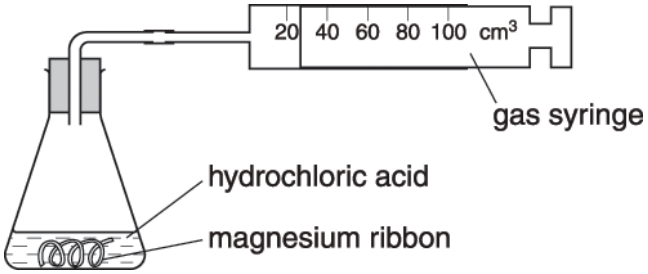
[2]

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21(a) Trevor and Julie investigate the reaction between magnesium and hydrochloric acid at 20 °C.

magnesium + hydrochloric acid → magnesium chloride + hydrogen

Look at the diagram. It shows the apparatus they use.

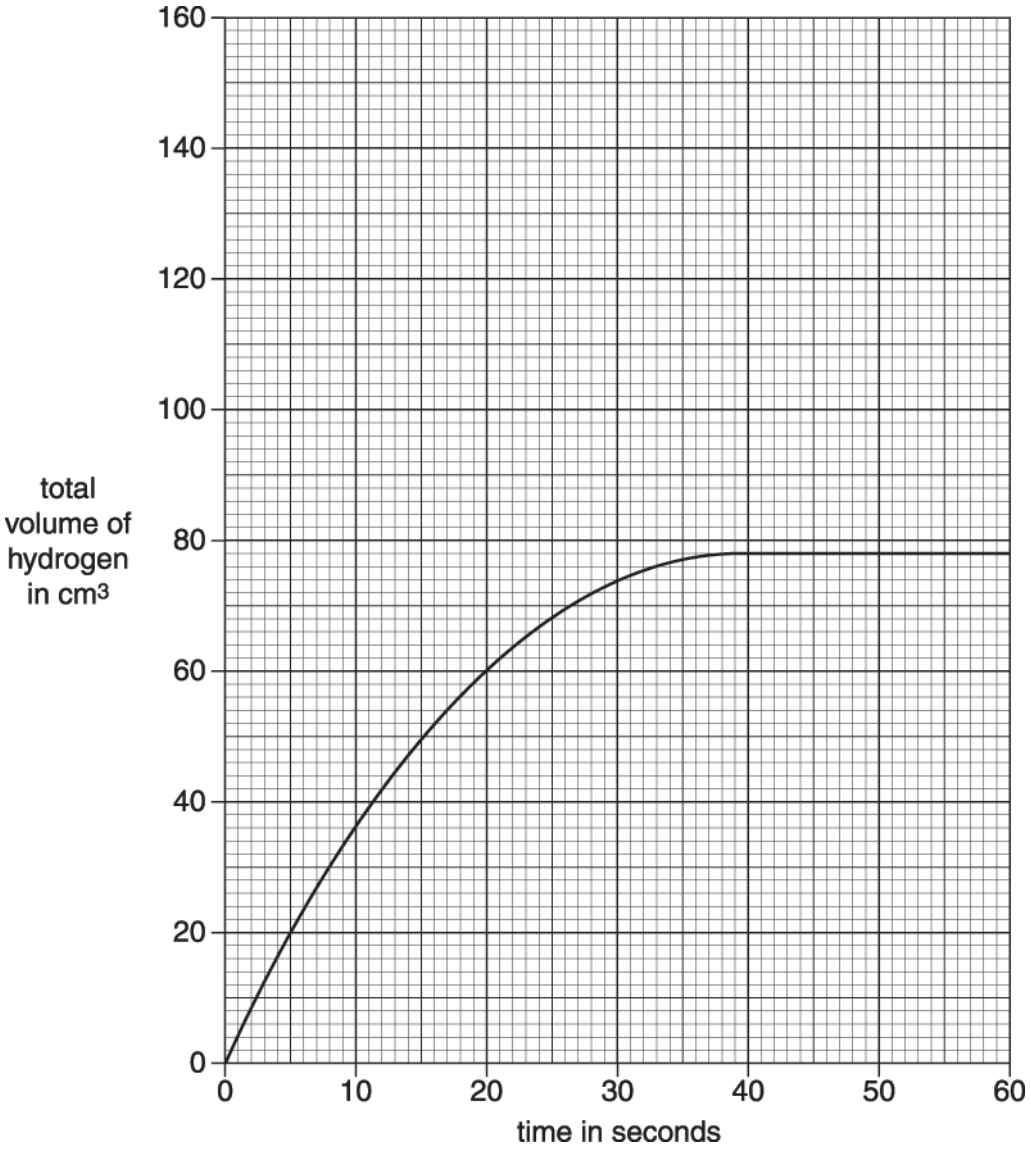


Look at the graph. It shows their results.

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(i) What is the volume of hydrogen made after 25 seconds?

answer _____ cm^3

[1]

(ii) How long does it take for the reaction to stop?

answer _____ seconds

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[1]

(iii) Trevor and Julie repeat the experiment.

They keep everything the same except the temperature.

They increase the temperature from 20 °C to 35 °C.

On the grid, sketch the graph of the results they should get.

[1]

(b) Magnesium is the **limiting reactant** in this reaction.

What is meant by limiting reactant?

---

[1]

22(a) This question is about acids and alkalis.

Indicators change colour in acids and alkalis.

Look at the table about some indicators.

Indicator	Colour in		
	Acid	Neutral	Alkali
litmus	red	purple	blue
phenolphthalein	colourless	colourless	_____
universal indicator	red, orange or yellow	_____	blue or purple

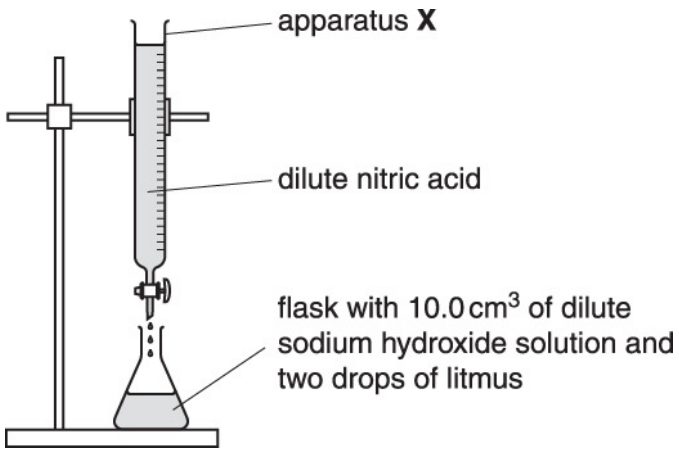
Complete the table.

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(b) Cristina does a titration.

She uses dilute nitric acid and an alkali called sodium hydroxide solution.

Look at the apparatus she uses.



(i) What is the name of apparatus **X**?

---

[1]

(ii) Cristina uses a pipette to measure the 10.0 cm^3 of sodium hydroxide solution.



Describe **one** safety precaution that Cristina takes when using the pipette.

Explain why this safety precaution is needed.

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---

[2]

(iii) Cristina slowly adds dilute nitric acid to the flask.

She keeps adding the acid until all the sodium hydroxide is neutralised.

Write about how Cristina can tell when the sodium hydroxide has been neutralised.

---

[2]

23(a) Ethanoic acid, $C_2H_4O_2$, can be made by several different processes.

Three of these are process **R**, process **S** and process **T**.

In process **R**, methanol reacts with carbon monoxide.

$$CH_4O + CO \rightarrow C_2H_4O_2$$

This Process **R** has 100% atom economy.

Explain how you can tell this from the symbol equation.

---

[1]

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(b) In process **S**, sodium ethanoate, $NaC_2H_3O_2$, reacts with sulfuric acid.

$$2NaC_2H_3O_2 + H_2SO_4 \rightarrow Na_2SO_4 + 2C_2H_4O_2$$

Look at the table of relative formula masses, M_r.

Substance	Relative formula masses, M_r
$NaC_2H_3O_2$	82
H_2SO_4	98
Na_2SO_4	142
$C_2H_4O_2$	60

(i) A mass of 8.2 g of sodium ethanoate reacts with excess sulfuric acid.

What mass of ethanoic acid, $C_2H_4O_2$, can be made?

---

mass of ethanoic acid = _____ g

[2]

(ii) Calculate the **atom economy** for process **S**.

Sodium sulfate, Na_2SO_4, is a waste product.

---

atom economy = _____ %

[2]

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(c) In process **T**, hydrocarbons are oxidised to make ethanoic acid.

Mike predicts that 5.2 tonnes of ethanoic acid should be made.

The factory actually makes 2.4 tonnes of ethanoic acid.

(i) Calculate the percentage yield of ethanoic acid.

Write your answer to **two** significant figures.

---

percentage yield = _____ %

[2]

(ii) Describe one disadvantage of having a percentage yield of this value.

---

[1]

24 Magnesium sulfate and magnesium nitrate are both used as fertilisers.

Magnesium nitrate is made by a neutralisation reaction.

Look at the equation for the reaction.

$$2HNO_3 + MgO \rightarrow Mg(NO_3)_2 + H_2O$$

Water is a waste product.

Show that the atom economy for the reaction is 89% and explain why it is important that the atom economy for a reaction is as high as possible.

The relative atomic masses (A_r) for H = 1, N = 14, O = 16 and Mg = 24.

The quality of written communication will be assessed in your answer to this question.

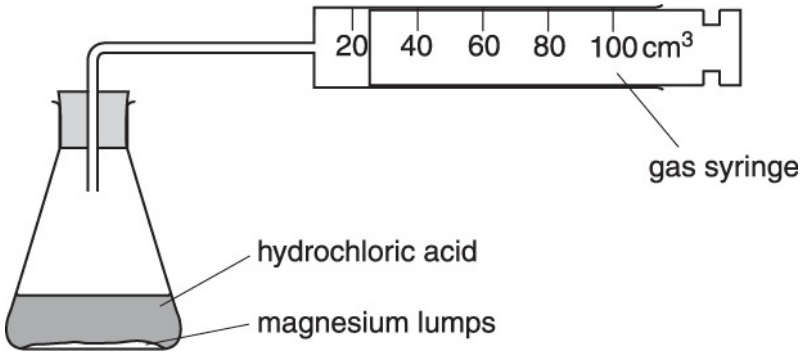
[6]

25 Hilary investigates the reaction between magnesium, Mg, and hydrochloric acid, HC*l*.

Magnesium chloride, $MgCl_2$, and hydrogen, H_2, are made.

Look at the diagram.

It shows the apparatus she uses.



Hilary measures the total volume of gas in the syringe every 10 seconds.

Look at the graph opposite. It shows her results.

(i) How long does it take for the reaction to stop?

answer _____ seconds

[1]

(ii) Calculate the **rate of reaction** during the first **10 seconds** of this experiment.

_____

_____

answer _____ cm^3/s

[1]

(iii) Hilary repeats the experiment.

She uses the same mass of magnesium and the same volume and concentration of acid.

This time she uses magnesium **powder**.

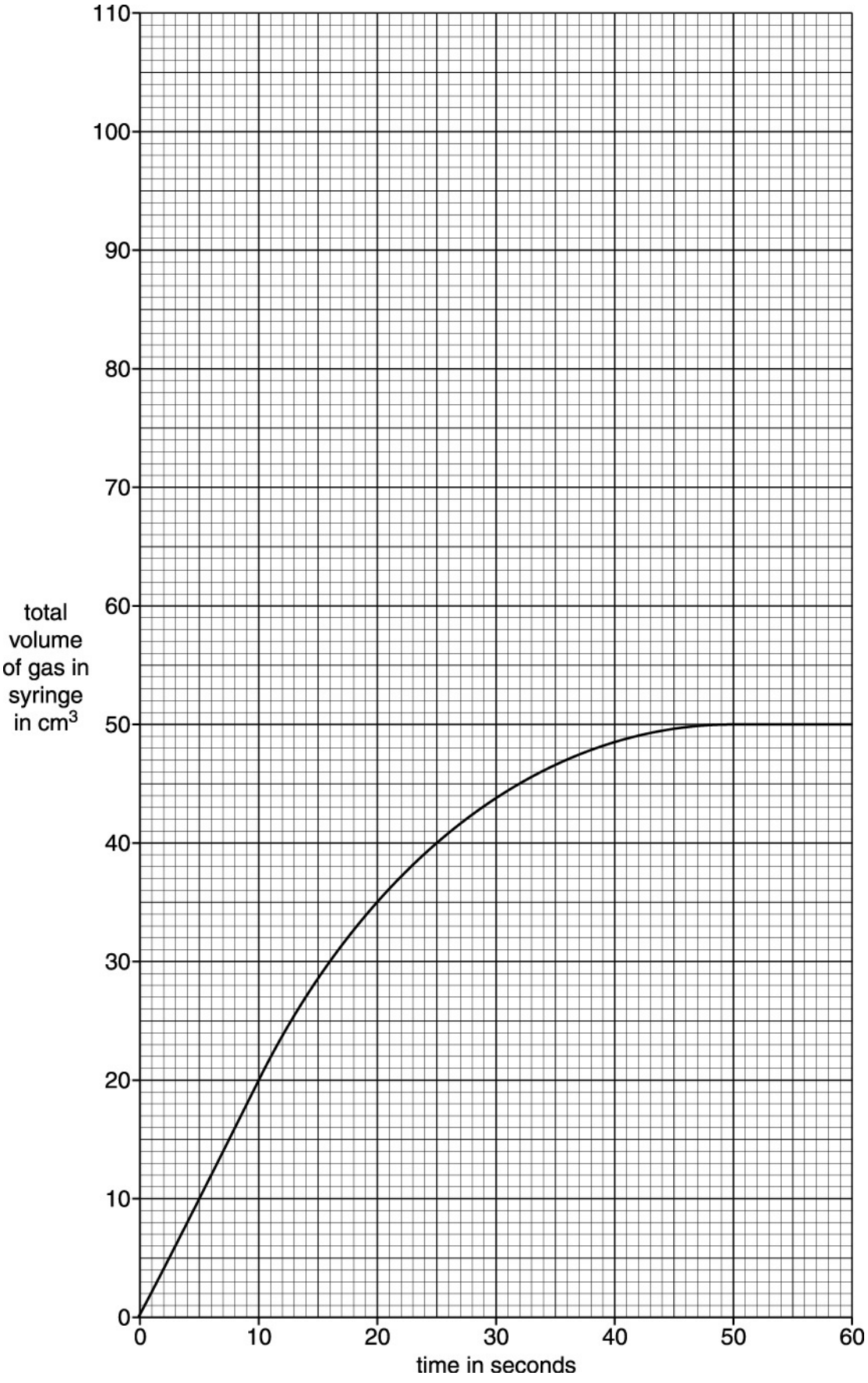
On the **grid** sketch the curve she gets.

[2]

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26 Hydrogen peroxide can also be made from barium peroxide.

barium peroxide + sulfuric acid → hydrogen peroxide + barium sulfate

BaO_2 + H_2SO_4 → H_2O_2 + $BaSO_4$

The table shows the relative formula masses, M_r, of the substances in the symbol equation.

Substance	Relative formula mass, M_r
BaO_2	169
H_2SO_4	
H_2O_2	34
$BaSO_4$	233

(i) Calculate the relative formula mass, M_r, of sulfuric acid, H_2SO_4.

Put your answer in the table.

The relative atomic mass, A_r, of H = 1, O = 16 and S = 32.

[1]

(ii) Barium sulfate is a waste product in this reaction.

Calculate the atom economy for this reaction.

atom economy = _____ %

[2]

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27(a) John and Sue investigate the decomposition of copper carbonate.

Copper carbonate, $CuCO_3$, breaks down into copper oxide, CuO, and carbon dioxide, CO_2.

Write the **balanced symbol** equation for this reaction.

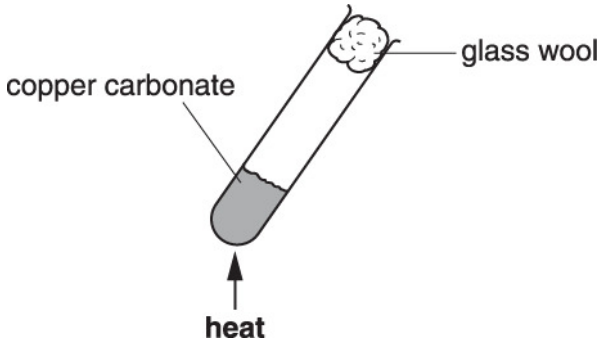
[1]

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(b) Look at the diagram. It shows the apparatus they use.



They measure the contents of the test tube before and after heating.

Look at their results.

	Mass in g
mass of contents before heating	12.40
mass of contents after heating	8.00

(i) Calculate the mass of **carbon dioxide** made.

---

answer _____ g

[1]

(ii) John and Sue repeat the experiment.

This time they use **24.80 g** of copper carbonate.

Calculate the mass of **carbon dioxide** they make this time.

answer _____ g

[1]

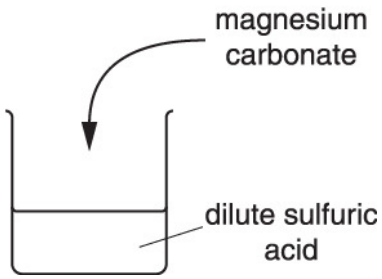
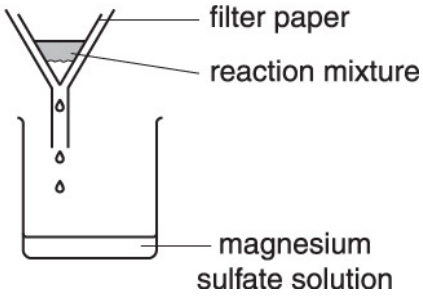
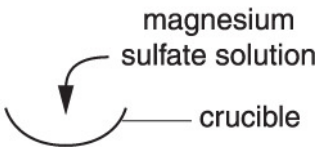
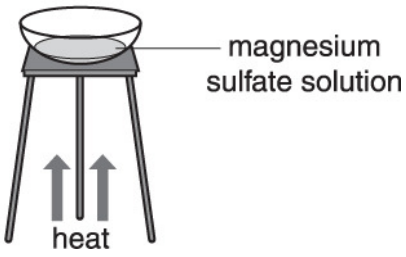
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28 Jim makes some magnesium sulfate.

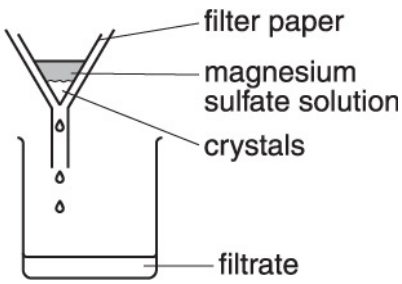
This is the method he uses.

Step **1**  	Jim adds magnesium carbonate to dilute sulfuric acid. He stops adding magnesium carbonate when the mixture stops bubbling.
Step **2**  	Jim filters the reaction mixture to remove excess magnesium carbonate.
Step **3**  	Jim pours the magnesium sulfate solution into a crucible.
Step **4**  	Jim evaporates half of the magnesium sulfate solution. He then leaves the concentrated solution to cool. Crystals are made in the solution.
	Jim filters off the crystals.

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Step **5**  	
Step **6**  	Jim dries the crystals of magnesium sulfate.

Jim predicts he should make **4 g** of magnesium sulfate.

He actually makes **3 g**.

Calculate the **percentage yield** for this reaction and suggest **reasons** why the yield is **less** than 100%.

The quality of written communication will be assessed in your answer to this question.

[6]

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29(a) This question is about acid-base titrations.

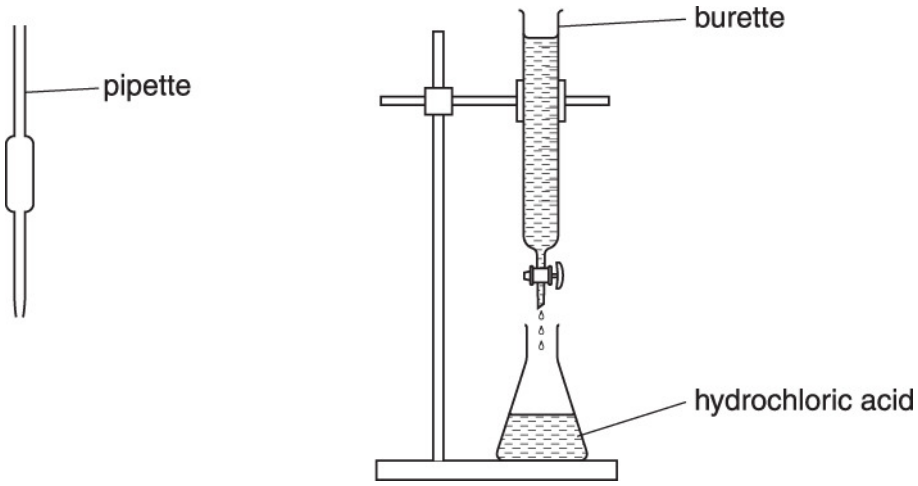
Complete the table to show the colours of acid-base indicators.

	Colour in	
Indicator	**Acid**	**Alkali**
litmus	red	blue
phenolphthalein	colourless	_____

[1]

(b) Brian neutralises dilute hydrochloric acid with sodium hydroxide solution.

Look at the apparatus he uses to do a titration.



He uses the pipette to measure 25.0 cm^3 of hydrochloric acid into the flask.

Describe how Brian completes the titration.

_____

_____

_____

_____

_____ **[3]**

(c) Brian does three more titrations.

Look at his results.

Titration number	1	2	3	4
Volume of sodium hydroxide added in cm^3	22.9	22.1	22.3	22.2

(i) Calculate the mean (average) volume of sodium hydroxide solution added for titrations **2**, **3** and **4**.

mean volume of sodium hydroxide solution added = _____ cm^3

[1]

(ii) Titration **1** was not included in the calculation of the mean volume of sodium hydroxide added.

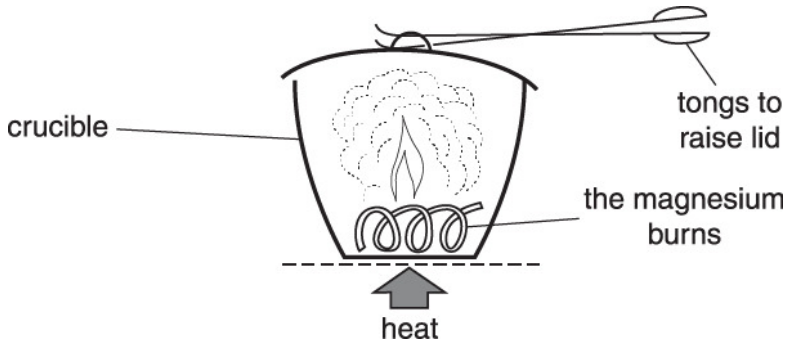
Suggest why.

_____ **[1]**

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30(a) Nick reacts magnesium with oxygen.

He heats the magnesium in a crucible.



The magnesium reacts with oxygen in the air.

Magnesium oxide is made.

magnesium + oxygen → magnesium oxide

Nick does the experiment four times with different masses of magnesium.

Look at the table of his results.

Mass of magnesium in g	Mass of oxygen used in g	Mass of magnesium oxide made in g
0.10	0.07	0.17
0.20	0.14	0.34
0.30	0.21	_____
0.40	_____	0.68

Complete the table.

[2]

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(b) How much magnesium would Nick need to make 1.7 g of magnesium oxide?

Explain how you worked out your answer.

---

[2]

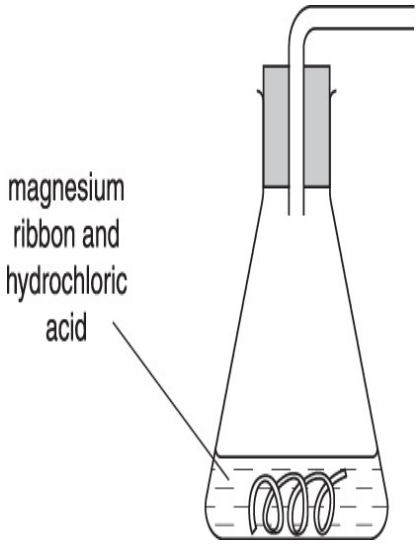
31 Trevor and Julie investigate the reaction between magnesium and hydrochloric acid at 20 °C.

magnesium + hydrochloric acid ? magnesium chloride + hydrogen

Hydrogen gas is given off in the reaction.

Look at the diagram. It shows **part** of the apparatus they use.

Complete the diagram to show how Trevor and Julie can **collect** and **measure** the volume of hydrogen made.



[2]

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32 Oskar investigates the thermal decomposition of zinc carbonate.

zinc carbonate → zinc oxide + carbon dioxide

Do Oskar's results support his prediction?

Explain your answer.

---

[2]

33(a) Hydrogen peroxide, H_2O_2, is used in some spacecraft to provide oxygen.

Hydrogen peroxide can be made from hydrogen and oxygen.

$$H_2 + O_2 \rightarrow H_2O_2$$

(i) This reaction has a 100% atom economy.

Explain how you can tell from the equation.

---

[1]

(ii) Industrial chemical processes should have as high an atom economy as possible.

Explain **two** reasons why.

---

[2]

(b)

$$H_2 + O_2 \rightarrow H_2O_2$$

Oskar uses 100 g of hydrogen.

(i) Show that the predicted yield of hydrogen peroxide is 1700 g.

$$H_2 + O_2 \rightarrow H_2O_2$$

The relative formula mass, M_r, of H_2 = 2, of O_2 = 32 and of H_2O_2 = 34.

---

[2]

(ii) Oskar's actual yield of hydrogen peroxide is 1530 g.

He predicts he should make 1700 g of hydrogen peroxide.

Calculate Oskar's percentage yield of hydrogen peroxide.

percentage yield = _____ %

[2]

(c) Hydrogen peroxide can also be made from barium peroxide.

barium peroxide	+	sulfuric acid	→	hydrogen peroxide	+	barium sulfate
BaO_2	+	H_2SO_4	→	H_2O_2	+	$BaSO_4$

The table shows the relative formula masses, M_r, of the substances in the symbol equation.

Substance	Relative formula mass, M_r
BaO_2	169
H_2SO_4	98
H_2O_2	34
$BaSO_4$	233

Barium sulfate is a waste product in this reaction.

Calculate the atom economy for this reaction.

atom economy = _____ %

[2]

34(a) Ethanoic acid, $C_2H_4O_2$, can be made by several different processes.

Three of these are process **R**, process **S** and process **T**.

In process **R**, methanol reacts with carbon monoxide.

$$CH_4O + CO \rightarrow C_2H_4O_2$$

(i) Process **R** has 100% atom economy.

What does 100% atom economy mean?

---

[1]

(ii) A factory uses 16 tonnes of methanol to make 30 tonnes of ethanoic acid.

What mass of carbon monoxide is needed?

---

mass of carbon monoxide = _____ tonnes

[1]

(b) In process **T**, hydrocarbons can be are oxidised to make ethanoic acid.

Mike predicts that 5.2 tonnes of ethanoic acid should be made.

The factory actually makes 2.4 tonnes of ethanoic acid.

Calculate the percentage yield of ethanoic acid.

Write your answer to **two** significant figures.

---

percentage yield = _____ %

[2]

35 Which statement describes the **atom economy** of a reaction?

A A measure of how many atoms in the reactants form the waste products.
B A measure of how many atoms in the reactants form the desired product.
C A measure of the actual yield of product compared to the predicted yield of product.
D A measure of how many atoms form waste products compared to desired products.

Your answer ☐ **[1]**

36 Which statement about **atom economy** is correct?

A A reaction that has only one product has a higher atom economy than a reaction that has two products, one of them being a waste product.
B A reaction with a low atom economy is more sustainable than a reaction with a high atom economy.
C A reaction with a low atom economy will usually produce less waste products than a reaction with a high atom economy.
D To calculate the atom economy of a reaction you need to know the expected yield and the actual yield of the products.

Your answer ☐ **[1]**

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37 Which of the following is the expression used to calculate concentration in g / dm^3?

A $\text{Concentration} = \dfrac{\text{mass of solute in g}}{\text{volume of solution in dm}^3}$

B $\text{Concentration} = \dfrac{\text{mass of solvent in g}}{\text{volume of solution in dm}^3}$

C $\text{Concentration} = \text{mass of solute in g} \times \text{volume of solution in dm}^3$

D $\text{Concentration} = \dfrac{\text{mass of solute in g} \times \text{volume of solution in dm}^3}{1000}$

Your answer [ ] [1]

38(a) In an experiment, a mixture of ammonium chloride and calcium hydroxide is heated.

Ammonia gas, NH_3, is made.

$2NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2NH_3 + 2H_2O$

A student adds 5.00 g of ammonium chloride to an excess of calcium hydroxide.

Calculate the maximum **volume of ammonia gas** that could be made at room temperature and pressure.

One mole of a gas occupies 24 dm^3 at room temperature and pressure.

Volume of ammonia gas = ... dm^3 **[2]**

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(b) In another titration 25.0 cm^3 of potassium hydroxide solution, KOH, are titrated with 0.200 mol / dm^3 sulfuric acid, H_2SO_4.

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

24.80 cm^3 of sulfuric acid are needed to neutralise 25.0 cm^3 of the potassium hydroxide solution.

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

Concentration = ... mol / dm^3 **[4]**

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(c) In another experiment a student reacts sodium hydroxide solution with dilute hydrochloric acid.

$NaOH + HCl \rightarrow NaCl + H_2O$

(i) 35.0 cm^3 of 0.075 mol / dm^3 hydrochloric acid, HCl, are added to 25.0 cm^3 of 0.100 mol / dm^3 sodium hydroxide solution, NaOH.

Use the information to determine which reactant is **in excess**.

---

[3]

(ii) To find the exact amount of dilute hydrochloric acid that reacts with 25.0 cm^3 of the sodium hydroxide solution, the student does a titration.

Look at the student's results. The rough titration is **not** shown.

	Titration 1	Titration 2	Titration 3	Titration 4
Final burette reading (cm^3)	36.30	38.60	39.25	38.30
Initial burette reading (cm^3)	0.00	2.80	4.05	2.10
Volume of acid used (cm^3)	36.30	35.80	35.20	36.20

Use the student's **concordant** results to calculate the mean volume of hydrochloric acid required.

Mean volume = ... cm^3 **[2]**

39 Hydrogen gas, H_2, reacts with oxygen gas, O_2, to make water, H_2O.

$2H_2 + O_2 \rightarrow 2H_2O$

What is the **atom economy** for this reaction?

M_r : H_2 = 2, O_2 = 32, H_2O = 18.

A 50%
B 53%
C 89%
D 100%

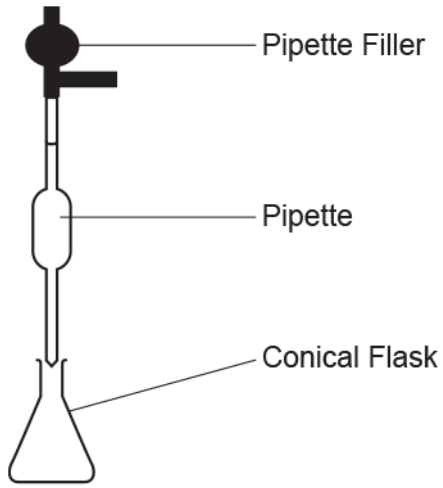
Your answer ☐ **[1]**

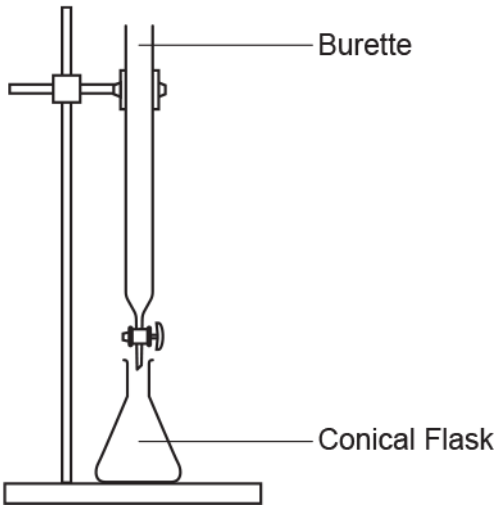
40(a) A student neutralises an alkali with an acid in a titration experiment.

Complete the word equation for the reaction of an acid with an alkali.

acid + alkali → ..... + ... **[2]**

(b) Look at the student's method for her experiment.





- Measure 25.0 cm^3 of alkali solution into a conical flask using a pipette.
- Add a few drops of universal indicator to the alkali solution.
- Fill the burette to above the 0.0 cm^3 line with acid.
- Quickly add the acid to alkali until the indicator changes colour.
- Repeat the experiment until consistent results are obtained.

Describe and explain **one** improvement the student should make to her method to get a more accurate titration result.

---

[2]

(c) The student repeats the experiment three times.

Look at the student's results.

Titration number	1	2	3
Volume of acid (cm^3)	25.75	23.60	23.70

Calculate the **accurate** volume of the acid that reacts with the alkali.

Accurate volume of acid = ... cm^3 **[2]**

41 Ammonium nitrate, NH_4NO_3, is fertiliser made from ammonia.

Ammonium nitrate is made by reacting ammonia with nitric acid.

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

(i) Calculate the mass of **ammonium nitrate** that could be made from 25.5 tonnes of ammonia.

A_r: H = 1.0, N = 14.0, O = 16.0

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Mass of ammonium nitrate = ... tonnes **[3]**

(i) A student makes some ammonium nitrate in the laboratory.

He predicts that he should make 12.5 g of ammonium nitrate.

His percentage yield is 80%.

Calculate the **actual mass** of ammonium nitrate that the student makes.

Actual mass of ammonium nitrate = ... g **[2]**

42 Hydrogen gas, H_2, reacts with oxygen gas, O_2, to make water, H_2O.

$2H_2 + O_2 \rightarrow 2H_2O$

What is the **atom economy** for this reaction?

M_r: $H_2 = 2$, $O_2 = 32$, $H_2O = 18$

A 50%
B 53%
C 89%
D 100%

Your answer ☐ **[1]**

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43 In the Haber process, nitrogen reacts with hydrogen to make ammonia.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

What is the maximum volume of ammonia, NH_3, that can be made from $150cm^3$ of hydrogen, H_2?

A $50cm^3$
B $100cm^3$
C $225cm^3$
D $450cm^3$

Your answer ☐ [1]

44 Which is the correct expression for calculating the concentration of a solution in g / dm^3?

A $$\text{Concentration} = \frac{\text{volume of solution in dm}^3}{\text{mass of solute in g}}$$

B $$\text{Concentration} = \frac{\text{amount of solute in mol}}{\text{mass of solute in g}}$$

C $$\text{Concentration} = \frac{\text{mass of solute in g}}{\text{volume of solution in cm}^3 \times 1000}$$

D $$\text{Concentration} = \frac{\text{mass of solute in g}}{\text{volume of solution in dm}^3}$$

Your answer ☐ [1]

45 Chemists often have a choice of reaction pathway when making a new product.

Which factor do chemists consider when choosing a reaction pathway?

A Disposal of product
B Price they can charge for the product
C Rate of reaction
D Usefulness of waste reactants

Your answer ☐ [1]

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46 Ammonium nitrate, NH_4NO_3, is a fertiliser made from ammonia.

Ammonium nitrate is made by reacting ammonia with nitric acid.

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

(i) Calculate the mass of **ammonium nitrate** that could be made from 25.5 tonnes of ammonia.

A_r: H = 1.0, N = 14.0, O = 16.0

Mass of ammonium nitrate = ... tonnes **[3]**

(ii) A student makes some ammonium nitrate in the laboratory.

He predicts that he should make 12.5 g of ammonium nitrate.

His percentage yield is 80%.

Calculate the **actual mass** of ammonium nitrate that the student makes.

Actual mass of ammonium nitrate ..... g **[2]**

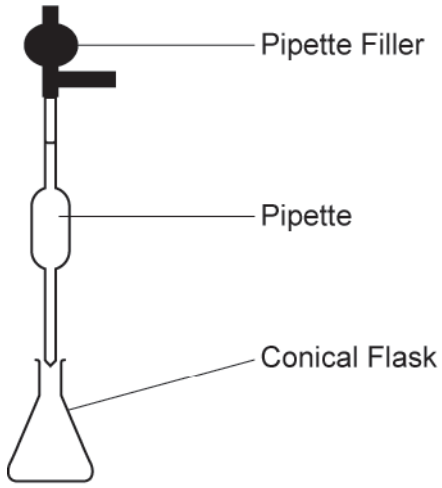
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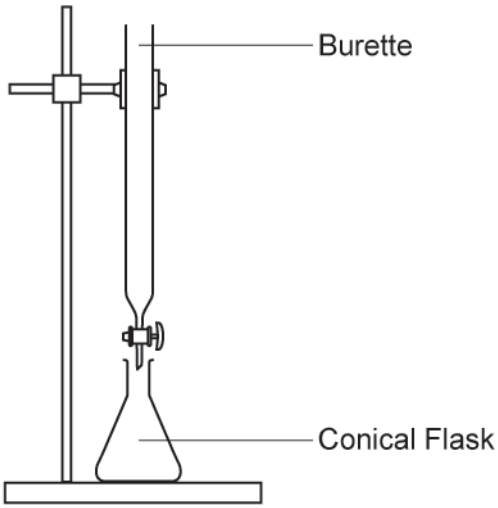
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47(a) A student neutralises potassium hydroxide with dilute sulfuric acid in a titration experiment.

Look at the student's method for her experiment.





- Measure 25.0 cm^3 of 0.200mol / dm^3 potassium hydroxide into a conical flask using a pipette.
- Add a few drops of universal indicator to the potassium hydroxide.
- Fill the burette to above the 0.00 cm^3 line with dilute sulfuric acid.
- Quickly add the dilute sulfuric acid to the potassium hydroxide until the indicator changes colour.
- Repeat the experiment.

Describe and explain **one** improvement the student should make to her method to get a more accurate titration result.

---

[2]

(b) The student repeats the experiment four times.

Look at the student's results.

Titration number	1	2	3	4
Volume of acid (cm^3)	25.75	23.60	23.70	23.65

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(i) Calculate the **accurate** volume of the acid that reacts with the alkali.

Accurate volume of acid = ... cm^3 **[2]**

(ii) Look at the equation for the reaction between sulfuric acid and potassium hydroxide.

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$

Use your answer from part **(i)** to calculate the concentration of the dilute sulfuric acid, H_2SO_4, that reacted with the 25.0 cm^3 of 0.200mol / dm^3 potassium hydroxide.

Give your answer to **3** significant figures.

Concentration of dilute sulfuric acid = ... mol / dm^3 **[4]**

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48(a) A student investigates the reactivity of four metals, **A**, **B**, **C** and **D**.

He adds a small piece of each metal to cold water.

He then adds a small piece of each metal to dilute hydrochloric acid.

Look at his results.

"

Metal	Observations in water	Observations in dilute hydrochloric acid
A	slow bubbling	very fast bubbling
B	no reaction	no reaction
C	fast bubbling	very fast bubbling
D	no change	slow bubbling

The piece of metal **C** used by the student produces 30 cm^3 of hydrogen gas when it reacts with the dilute hydrochloric acid at room temperature and pressure.

(i) Calculate the number of **moles** of hydrogen gas produced.

One mole of any gas occupies 24 dm^3 at room temperature and pressure.

Moles of hydrogen gas = ... **[2]**

(ii) Use your answer from **(i)** to calculate the **mass** of hydrogen gas produced.

Mass of hydrogen gas = ... g **[1]**

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(b) Chromium metal, Cr, reacts with nickel sulfate solution, $NiSO_4$. Solid nickel is made.

Two possible equations for this reaction are:

Equation 1 $Cr + NiSO_4 \rightarrow CrSO_4 + Ni$

Equation 2 $2Cr + 3NiSO_4 \rightarrow Cr_2(SO_4)_3 + 3Ni$

10.40 g of chromium metal reacts with excess nickel sulfate solution to make 17.61 g of nickel.

Deduce which equation, **1** or **2**, represents the reaction which takes place.

A_r: Cr = 52.0, Ni = 58.7

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[3]

END OF QUESTION PAPER