Answer **all** the questions.

1. 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?

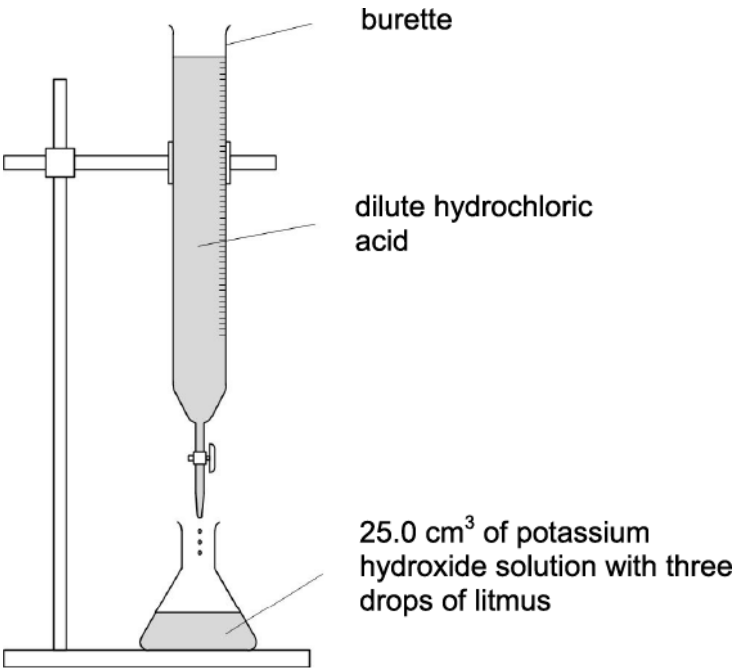
A 43.0 g
B 44.0 g
C 58.0 g
D 60.0 g

Your answer ☐

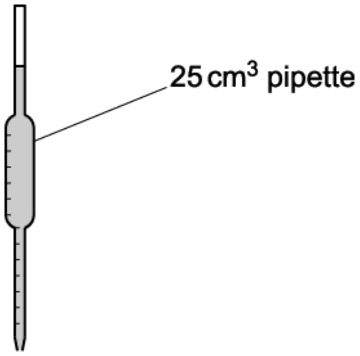
[1]

2(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.



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

____

____

____ **[2]**

(b). 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.

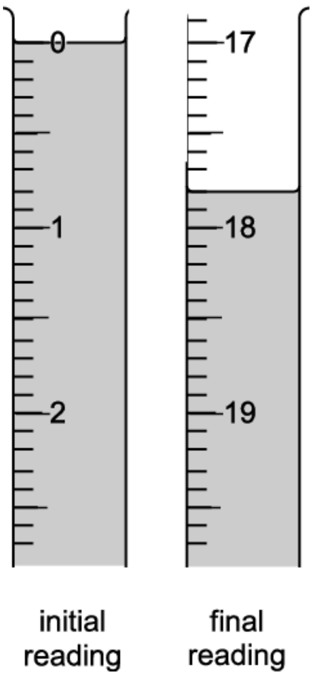
She then measures the volume of the hydrochloric acid again.

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

-- **[2]**

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

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]**

(d). 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]**

3. 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]

4. 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]

5. 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]

6. 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]

7. 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 ☐

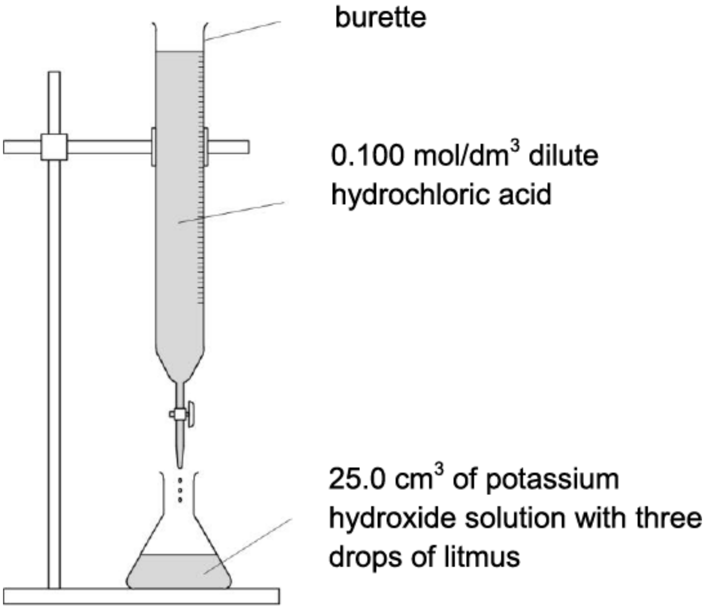
[1]

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

Hydrochloric acid neutralises the alkali potassium hydroxide.

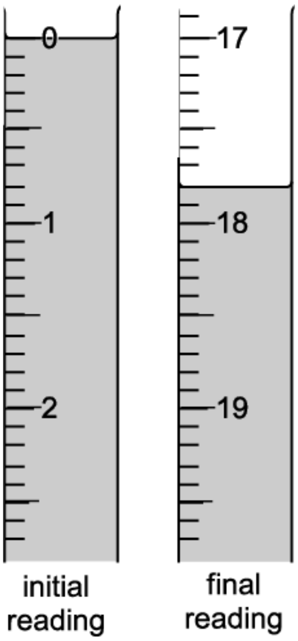
$$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$$

Look at the apparatus she uses.



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

First titration



Here is Sarah's results table:

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

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

carbon dioxide + hydrogen ⇌ methane + 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.

____

____

____

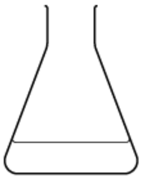
Percentage yield = ____________________________ % **[2]**

10. Stewart and Claire want to do a titration.

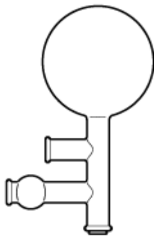
Look at the diagrams. They show some of the apparatus they use.

burette

pipette



flask



pipette filler

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]

11(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, 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]

(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]

12(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, *M*r**
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]

13. 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]**

14. 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.

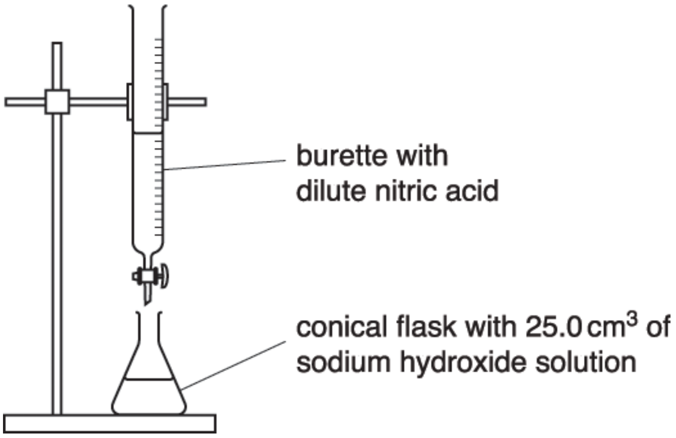
In each example explain why it is important to dilute the solution.

[2]

15(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.

--- **[2]**

(b). Sam does three titrations.

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

second
titration

first reading 5.2
second burette
reading
24.1 cm^3

rough
titration

burette reading
goes from 0.0 to
20.1 cm^3

third
titration

first burette reading 24.2
second reading 43.1 cm^3

(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.

Average (mean) titre = _______________ cm^3

[2]

16(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]

17(a). 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]

(b). 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.

____

____

____ **[2]**

18. 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]

19. 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]

20(a). 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]

(b). 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.

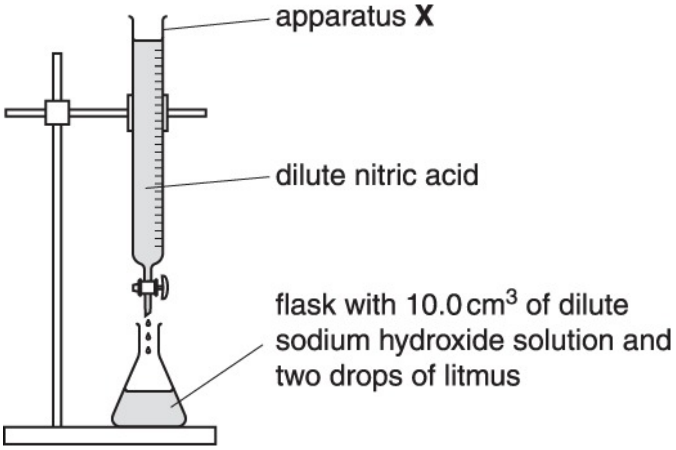
Explain how you can tell this from the symbol equation.

[1]

21(a). 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.

____

____ **[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]**

(b). 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.

22. Hydrogen peroxide can also be made from barium peroxide.

$$\text{barium peroxide} + \text{sulfuric acid} \rightarrow \text{hydrogen peroxide} + \text{barium sulfate}$$

$$BaO_2 + H_2SO_4 \rightarrow H_2O_2 + BaSO_4$$

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.

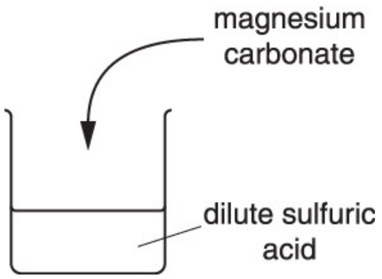
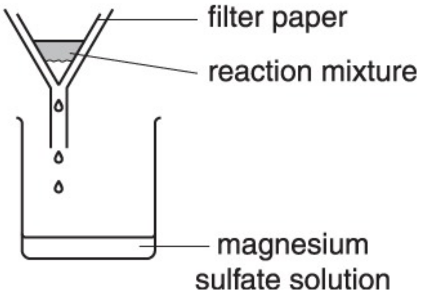
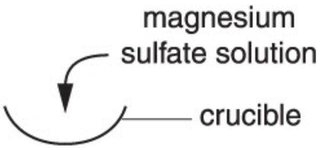
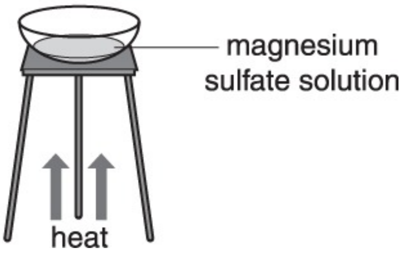
Calculate the atom economy for this reaction.

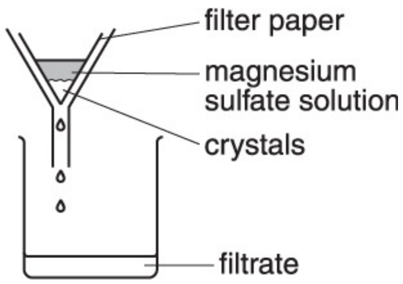
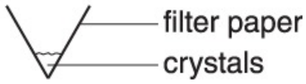
atom economy = _________________ %

[2]

23. 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.

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]

24. 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]

25. 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]**

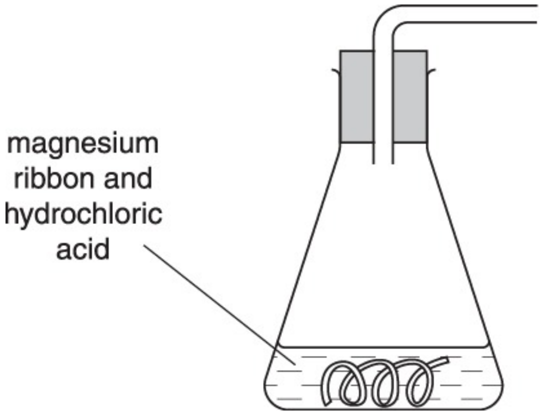
26. Trevor and Julie investigate the reaction between magnesium and hydrochloric acid at 20 °C.

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.

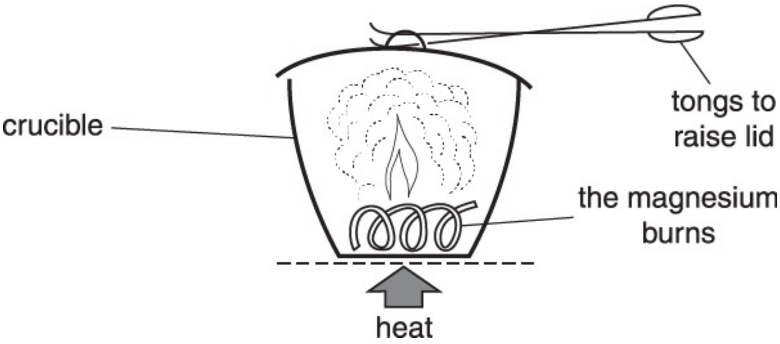
Complete the diagram to show how Trevor and Julie can **collect** and **measure** the volume of hydrogen made.



[2]

27(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]

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

Explain how you worked out your answer.

-- **[2]**

28. Brian neutralises dilute hydrochloric acid with sodium hydroxide solution.
He does four 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]**

29(a).

$$H_2 + O_2 \rightarrow H_2O_2$$

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]

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

$$\text{barium peroxide} + \text{sulfuric acid} \rightarrow \text{hydrogen peroxide} + \text{barium sulfate}$$

$$BaO_2 + H_2SO_4 \rightarrow H_2O_2 + BaSO_4$$

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]

30(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]

END OF QUESTION PAPER

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td></td><td></td><td>D</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>2</td><td>a</td><td></td><td>Use a pipette filler (1)
Potassium hydroxide is caustic / potassium hydroxide can burn skin (1)</td><td>2</td><td></td></tr>
<tr><td></td><td>b</td><td></td><td>When one drop makes the litmus change colour (1)
Correct colour change blue to red (1)</td><td>2</td><td>ALLOW use a pH probe = 1 mark
ALLOW gives a pH value of 7 when neutral = 1 mark</td></tr>
<tr><td></td><td>c</td><td>i</td><td><table>
<tr><th>Titration number</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>final reading in cm^3</td><td>17.8</td><td>37.5</td><td>32.1</td></tr>
<tr><td>initial reading in cm^3</td><td>0.0</td><td>20.4</td><td>15.0</td></tr>
<tr><td>titre (volume of acid added) in cm^3</td><td>17.8</td><td>17.1</td><td>17.1</td></tr>
</table></td><td>2</td><td>Correct burette readings = 1 mark
Correct titre = 1 mark
DO NOT ALLOW 0</td></tr>
<tr><td></td><td></td><td>ii</td><td>Yes
Titration 1 is a rough estimate / titration 1 is an outlier / titrations 2 and 3 are identical (1)</td><td>1</td><td></td></tr>
<tr><td></td><td>d</td><td></td><td>Atom economy = (M_r of desired products / sum of M_r of all products) × 100
= (101 ÷ 119) × 100 (1)
= 84.9 (%) (1)</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>9</td><td></td></tr>
<tr><td>3</td><td></td><td></td><td>A</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>4</td><td></td><td></td><td>C</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
5			D	1	
			Total	**1**	
6			17 (g) of ammonia makes 66 (g) of ammonium sulfate So 51 g makes 198 g of ammonium sulfate (1)	1	
			Total	**1**	
7			D	1	
			Total	**1**	
8	a		Mean titre = 17.1 (1) Because titration 1 is a rough estimate / titration 1 is an outlier / titrations 2 and 3 are identical (1)	2	**IGNORE** anything in the titration table
	b		Moles of acid = 0.00171 (1) Concentration of KOH = 0.0684 (1)	2	**ALLOW ECF** from incorrect titre / 0.100 × titre × 10^{-3} **ALLOW ECF** from incorrect moles providing answer is to 3 sig figs / moles÷volume
	c		M_r of KOH = 56.1 (1) Concentration of KOH = 3.84 (1)	2	**ALLOW** correct answer without working **ALLOW** 3.837 **ALLOW ECF** from incorrect M_r and / or incorrect concentration from (b) / M_r× conc
			Total	**6**	
9			Percentage yield = (actual yield ÷ predicted yield) × 100 / (2.2 ÷ 4.0) × 100 (1) 55 (1)	2	**ALLOW** full marks for answer with no working out
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
10			**[Level 3]** **Complete description of a titration to include detection of endpoint and safety precautions** Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **[Level 2]** **Description of a titration to include detection of endpoint** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **[Level 1]** **Rudimentary description of a titration** Quality of written communication impedes communication of the science at this level. (1 – 2 marks) **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	**This question is targeted at grades up to E** **Indicative scientific points at level 3 may include:** • many of the points at levels 1 and 2 and in addition • idea of repeating to obtain concordant results • use pipette filler to avoid sucking alkali or acid into mouth • safety goggles as liquids are corrosive • fill burette above eye level **Indicative scientific points at level 2 may include:** • acid in burette, alkali in flask (or vice versa) • use pipette to accurately measure alkali (or acid) • add acid to alkali (or vice versa) • use of an indicator • named indicator such as methyl orange, litmus or phenolphthalein • colour changes at end point or when solution is neutral • use of pH meter • idea of measuring titre **Indicative scientific points at level 1 may include:** • acid in burette, alkali in flask (or vice versa) • add acid to alkali (or vice versa) • use of safety goggles • use of pipette filler **Use the L1, L2, L3 annotations in RM Assessor; do not use ticks.** **Examiner's Comments** To gain credit at level 3 (5 – 6 marks) candidates needed to give a complete description of a titration including detection of the endpoint and safety precautions.

Question			**Answer/Indicative content**	**Marks**	**Guidance**
					Very few candidates attained the higher levels on this question. Examiners saw many answers which made no reference to the use of an indicator or a pH meter to detect the endpoint; this restricted marks to Level 1.
			Total	**6**	
11	a		32 (g) of methanol makes 60 (g) of ethanoic acid / 10 moles of methanol is used / 32 x 10 = 320 (1) So 320 (g) makes 600 (g) of ethanoic acid (1)	2	**allow** two marks for the correct answer of 600g even if no working out **Examiner's Comments** This question assessed various quantitative aspects of the specification. Both calculations differentiated well, with only the better candidates able to successfully attempt the question.
	b		atom economy = $\frac{60}{60+18}$ / $\frac{60}{46+32}$ / $\frac{60}{78}$ (1) **but** atom economy = $\frac{60}{60+18} \times 100$ / $\frac{60}{46+32} \times 100$ / $\frac{60}{78} \times 100$ (2)	2	**allow** atom economy formula in words for one mark i.e. atom economy = $\frac{\text{total Mr of desired products}}{\text{total Mr of all products}}$ x 100 (1) **Examiner's Comments** Both calculations differentiated well, with only the better candidates able to successfully attempt the question.
	c		percentage yield = $\frac{9.5}{9.8}$ (1) **but** percentage yield = $\frac{9.5}{9.8} \times 100$ (2)	2	**allow** percentage yield formula in words for one mark e.g. percentage yield = $\frac{\text{actual yield}}{\text{predicted yield}}$ x 100 or percentage yield = $\frac{\text{am}}{\text{pm}}$ x 100 **Examiner's Comments** More candidates were able to calculate the percentage yield than mass of product made or atom economy in (a) and (b). Many candidates did not understand the importance of either a high percentage yield or a high atom economy.
			Total	**6**	

Question			**Answer/Indicative content**	**Marks**	**Guidance**
12	a		46 (1)	1	**ignore** units **Examiner's Comments** Most candidates could correctly calculate the relative formula mass of ethanol.
	b		280 (g) (1)	1	unit **not** needed **ignore** incorrect units **Examiner's Comments** Just over half of all candidates could correctly work out the mass of carbon monoxide needed for the reaction.
	c		atom economy = $\frac{60}{60+18}$ / $\frac{60}{46+32}$ / $\frac{60}{78}$ (1) **but** atom economy = $\frac{60}{60+18}$ × 100 / $\frac{60}{46+32}$ × 100 / $\frac{60}{78}$ × 100 (2)	2	**allow** atom economy formula in words for one mark i.e. atom economy = $\frac{\text{total Mr of desired products}}{\text{total Mr of all products}}$ x 100 (1) or atom economy = $\frac{\text{total Mr of desired products}}{\text{total Mr of all reactants}}$ x 100 (1) **Examiner's Comments** Just over half of all candidates could correctly work out the mass of carbon monoxide needed for the reaction.
	d		percentage yield = $\frac{9.5}{9.8}$ (1) **but** percentage yield = $\frac{9.5}{9.8}$ × 100 (2)	2	**allow** percentage yield formula in words for one mark e.g. percentage yield = $\frac{\text{actual yield}}{\text{predicted yield}}$ x 100 or percentage yield = $\frac{\text{am}}{\text{pm}}$ x 100 **Examiner's Comments** Although better answered than part (d), a significant number of candidates omitted the question. Better candidates showed a good understanding of the ideas involved, scoring both marks.

Question			Answer/Indicative content	Marks	Guidance
			Total	**6**	
13		i	more sustainable / makes less or no **waste** products (1)	1	makes less waste is **not** sufficient **ignore** makes less products **ignore** it wastes less resources **Examiner's Comments** Many candidates did not understand the importance of either a high percentage yield or a high atom economy. It was not sufficient to just state 'so there is no waste'; the candidates had to refer to either the less waste products or less waste reactants.
		ii	less waste of reactants (1)	1	**allow** no need to recycle unreacted reactants **ignore** less waste / waste products **ignore** able to make more / more products made **Examiner's Comments** Many candidates did not understand the importance of either a high percentage yield or a high atom economy. It was not sufficient to just state 'so there is no waste'; the candidates had to refer to either the less waste products or less waste reactants.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
14			**any two from**: must dilute baby milk because harmful if too concentrated (1) dilute medicines to avoid giving overdoses or avoid harm (1) dilute concentrated fruit squashes to make sure the taste is not too strong (1)	2	**ignore** can have too many chemicals or preservatives **allow** idea that doses are weaker or could be harmful if left undiluted (1) **ignore** progressively dilute heroin to wean addicts off the drug **allow** if not are highly acidic (1) **Examiner's Comments** Better candidates usually scored both marks. The idea that medicines needed to be diluted to avoid overdose was a common answer gaining 1 mark. Understanding that foods such as cordials need to be diluted to avoid too strong a taste was less well understood.
			Total	**2**	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>15</td><td>a</td><td></td><td>(litmus changes) from blue or purple (1) to red (1)</td><td>2</td><td>allow one mark if the colours are reversed
allow pink for red (1)
allow changes from blue to green to red (1)

allow sudden change of colour of litmus for one mark if no other mark awarded

<u>Examiner's Comments</u>

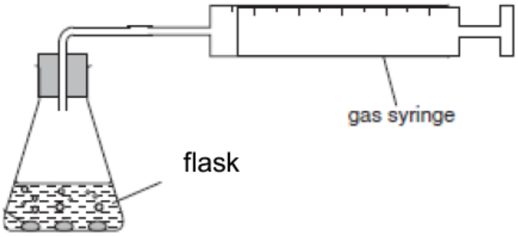
Few candidates correctly stated that the colour change was from blue to red. ‘ Colourless’ and ‘orange’ featured quite prominently. Pink was an acceptable alternative to red.</td></tr>
<tr><td></td><td>b</td><td>i</td><td>suitable table for all three titrations but no units or titres or numbers (1)
BUT
table for all three titrations including data, units and titres (2)</td><td>2</td><td>
<table>
<tr><th>(Titration number)</th><th>Rough / 1</th><th>2</th><th>3</th></tr>
<tr><td>final reading / cm^3</td><td>20.1</td><td>24.1</td><td>43.1</td></tr>
<tr><td>Starting reading / cm^3</td><td>0.0</td><td>5.2</td><td>24.2</td></tr>
<tr><td>titre / cm^3</td><td>20.1</td><td>18.9</td><td>18.9</td></tr>
</table>

allow volume of acid instead of titre
allow first instead or reading 1 instead of starting
allow second or reading 2 instead of final
allow the final and starting rows to be reversed.
allow similar table with the rows and columns reversed

<u>Examiner's Comments</u>

just over half of all candidates scored 1 mark for constructing a table which included all three titrations but without units, titres or numbers. Very few candidates scored both marks.</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
		ii	use titrations **2** and **3** / use the last two titrations (1) titre = 18.9 (1)	2	**allow** do not use the rough value (1) **allow** ecf from wrong titres in (i) or from wrong choice of titrations but answer must be to one decimal place e.g if all three readings used then 19.3 (1) and e.g. if rough and 1 taken or rough and 2 taken then 19.5 (1) **Examiner's Comments** was poorly answered. Only the best candidates selected titrations 2 and 3. 'All three' was a common incorrect response, although error carried forward was employed in that case for the second mark. Many candidates calculated the mean using burette readings rather than the titre.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
16	a		**any two from:** correct piece of apparatus to collect and measure gas e.g. (gas) syringe, upturned measuring cylinder with water or upturned burette with water (1) workable and gas tight (1)	2	 The measuring apparatus must be graduated and does not need to be assembled. The apparatus does not need to be named if there is no ambiguity from the diagram **allow** even if the syringe / measuring cylinder is not graduated **allow** the tube can be a single line **ignore** if tube does not appear to go through the stopper **not** the delivery tube must not go in the reaction mixture **?Examiner's Comments?**? Candidates need to take more time when drawing diagrams of apparatus in order to avoid silly errors and mistakes. Most candidates decided to use a gas syringe, although some forgot to show the graduations on the gas syringe. Candidates were often able to draw a diagram to show the use the gas syringe as part as a workable method. Other candidates used a burette and a measuring cylinder but they often did not include them as part of a suitable diagram, for example did not collect the gas by displacement of water. A common misconception was to show the apparatus but not set up as a working method.
	b	i	Moles = 0.0025 / 2.5 × $10^{?3}$ (1)	1	**?Examiner's Comments?**? Many candidates did not understand the relationship between volume, molar volume and moles and as a result did not get the correct answer of 0.0025 moles. A typical incorrect answer was 1.44 moles.

Question			Answer/Indicative content	Marks	Guidance
		ii	Mass = 0.25 (g) / 2.5 × $10^{?1}$ (1)	1	**allow** ecf from number of moles, i.e. moles × 100 **<u>?Examiner's Comments</u>?**? Many candidates could not sure the relationship between molar mass, moles and mass in (ii) and as a result did not multiply the answer to (i) by 100. A significant proportion of candidates left (ii) blank.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
17	a		**LOOK FOR ANSWER FIRST OF ALL IF concentration = 0.08 (mol/dm^3) AWARD 3 MARKS** no of moles in acid = $\frac{20 \times 0.100}{1000}$ / 0.02×0.100 / 0.002(1) moles of alkali = 0.002 / moles of acid = moles of alkali (1) concentration = 0.08 (mol/dm^3) (1)	3	If answer correct **ignore** any working out **allow** ecf from moles of acid **unit** not needed **allow** ecf from moles of alkali ie conc = $\frac{moles}{0.025}/\frac{moles \times 1000}{25}$ **Examiner's Comments** A small proportion of candidates left this question blank. Candidates often got three marks, with a correct answer of 0.08 mol/dm3, or no marks. Candidates often did not organise their answers and the answer space was full of numbers and equations that made little sense. Candidates would be advised to calculate the moles of hydrochloric acid, then to state that this was the same as the moles of the alkali and finally calculate the concentration of the alkali. By organising their answer candidates will get the opportunity to be awarded marks for error carried forward.

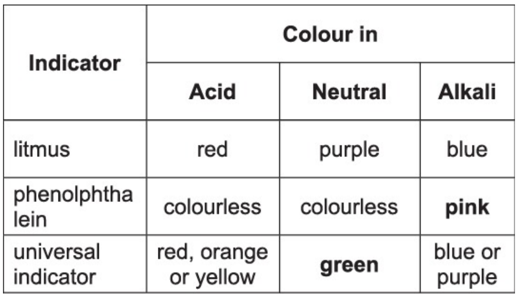
Question			Answer/Indicative content	Marks	Guidance
	b		single indicator or phenolphthalein only gives a single **colour** change / gives a sudden **colour** change (1) mixed indicator or universal indicator can give several **colour** changes / mixed indicator gives a gradual **colour** change (1)	2	**The first mark awarded must refer to a colour change** ?**allow** phenolphthalein only has two **colours** / is either **pink** or **colourless** / phenolphthalein changes **colour** at the end-point **ignore** clear **allow** universal indicator shows many **colours** / universal indicator changes **colour** all the time **Examiner's Comments** Although candidates often appreciated that there was a sudden colour change with phenolphthalein and a gradual colour change with universal indicator, many did not include the word colour in their answer.
			Total	**5**	
18		i	46 % (2) but 46.2 / 46.15 / 46.154 (1)	2	answer must have **two** sig figs for two marks **allow** one mark for $\frac{2.4}{5.2}\times100$ **Examiner's Comments** Most candidates correctly calculated the percentage yield, but many did not give their answer to two significant figures and therefore scored only 1 mark.
		ii	waste a lot of starting material / wastes reactants (1)	1	**ignore** waste products **ignore** just 'a lot of waste' **ignore** wastes lots of resources **Examiner's Comments** Good responses appreciated that a low percentage yield wastes reactants. Most answers were expressed in terms of a large amount of waste products.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
19			**Level 3 (5–6 marks)** **Calculates the atom economy for the given reaction** **AND** **Explains clearly why an industrial process should have as high an atom economy as possible.** Quality of written communication does not impede communication of the science at this level. **Level 2 (3–4 marks)** **Calculates the atom economy for the given reaction** **OR** **Gives at least two reasons why an industrial process should have as high an atom economy as possible.** Quality of written communication partly impedes communication of the science at this level. **Level 1 (1–2 marks)** **Gives a reason why an industrial process should have as high an atom economy as possible** **OR** **calculates the required formula masses of magnesium nitrate and water.** Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science such as repeating the question. Answer not worthy of credit.	6	**This question is targeted at grades up to A*.** **Indicative scientific points may include:** **reasons for need for high atom economy:** • to reduce the production of unwanted products (makes less waste is **not** sufficient) • to make the process more sustainable • in this reaction water is the only unwanted product so the process is very green. **calculation of atom economy:** • recall $\text{atom economy} = \frac{\text{molecular mass of all of the desired products}}{\text{sum of all of the molecular masses of all of the products}} \times 100\%$ • formula mass of magnesium nitrate = 148 • formula mass of water = 18 • formula mass of all products = 166 • atom economy = 89%. **Use the L1, L2, L3 annotations in scoris; do not use ticks.** **Examiner's Comments** This 6 mark question focused on the concept of atom economy and was targeted at high demand, i.e. grades B-A*. At the simplest level, a candidate who calculated the required formula masses of magnesium nitrate and water, or gave a reason why an industrial process should have as high an atom economy as possible, scored Level 1. It was usually the formula mass calculation that gained credit at this level. To gain Level 2 candidates needed to show clearly, by calculation, that the atom economy for the reaction is 89%. Alternatively candidates could give two reasons why an industrial process should have as high an atom economy as

Question			Answer/Indicative content	Marks	Guidance
					possible, although marks scored in this way were again rarer. As in the other 6 mark questions on the paper, candidates had to address all aspects of the question to gain credit at level 3 (5-6 marks). Many candidates did not explain why an industrial process needs to have as high an atom economy as possible so did not gain credit beyond Level 2.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
20	a	i	idea that 164g of sodium ethanoate makes 120g of ethanoic acid / idea that 82g of sodium ethanoate makes 60g of ethanoic acid (1) **but** mass is 6 (2)	2	units **not** needed **Examiner's Comments** Candidates who understood the idea of reacting masses were able to correctly calculate the mass of ethanoic acid as 6g. Some candidates tried to calculate a percentage yield or atom economy. Few candidates scored 1 mark for correct working out.
		ii	$\frac{(2\times60)}{(2\times60)+142}\times100$ **or** $\frac{120}{262}\times100$ **or** $\frac{(2\times60)}{(2\times82)+98}\times100$ **or** $\frac{120}{164+98}\times100$ (1) **but** 45.8% (2)	2	**allow** full marks for correct answer despite working out **allow** 46% (2) **Examiner's Comments** Candidates found the atom economy calculation challenging.
	b		no undesired products made / no waste products made / all the atoms that react end up in the product / only **one** product made (1)	1	**not** the same number of atoms on each side of the equation **Examiner's Comments** Good responses appreciated that the process has 100% atom economy because there are no waste products. Candidates who failed to gain credit gave answers in terms of conservation of mass.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
21	a	i	burette (1)	1	**Examiner's Comments** Less than half of candidates could identify a burette in part (i). Common incorrect answers included 'measuring cylinders', ' pipettes', 'test tube' and 'measuring tube'.
		ii	pipette filler (1) because the liquid is corrosive or harmful or an irritant (1) **or** (safety) goggles (1) because the liquid is corrosive or harmful or an irritant (1)	2	**allow** avoids getting liquid in mouth (1) **ignore** idea that protects eyes from chemicals **allow** wear gloves (1) because the liquid is corrosive or harmful or an irritant (1) **allow** protective clothing (1) because the liquid is corrosive or harmful or an irritant (1) **Examiner's Comments** The most common safety precautions were to use goggles, gloves or protective clothing. Few candidates mentioned the use of a pipette filler. The idea that these precautions are necessary as the liquids used are corrosive, harmful or irritants was not well understood.
		iii	idea of a colour change (1) **but** idea of a sudden colour change (2) **or** starts blue (1) then it changes to purple or red (1)	2	**Examiner's Comments** Most candidates mentioned a colour change and scored 1 mark. Fewer stated the sudden nature of the colour change or gave the correct colours for before and after neutralisation for the second mark.

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>b</td><td></td><td><table><tr><th rowspan="2">Indicator</th><th colspan="3">Colour in</th></tr><tr><th>Acid</th><th>Neutral</th><th>Alkali</th></tr><tr><td>litmus</td><td>red</td><td>purple</td><td>blue</td></tr><tr><td>phenolphthalein</td><td>colourless</td><td>colourless</td><td>pink</td></tr><tr><td>universal indicator</td><td>red, orange or yellow</td><td>green</td><td>blue or purple</td></tr></table>
phenolphthalein row correct (1)
universal indicator row correct (1)</td><td>2</td><td>allow purple / lilac / red (1)
Examiner's Comments
Just under half of candidates could recall one of the colours correctly and a further quarter correctly identified both. ‘Green’ was the most common correct answer.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>7</td><td></td></tr>
<tr><td>22</td><td></td><td>i</td><td>98 (1)</td><td>1</td><td>Examiner's Comments
Some candidates missed out the question but others were able to calculate the relative formula mass as 98. Most candidates could not calculate the atom economy as 12.7%.</td></tr>
<tr><td></td><td></td><td>ii</td><td>LOOK FOR ANSWER FIRST OF ALL IF atom economy = 12.7(34) OR 13 AWARD 2 MARKS
$\frac{34}{169+98}\times100$ or $\frac{34}{267}\times100$ or $\frac{34}{34+233}\times100$ (1)
12.7 (1)</td><td>2</td><td>allow $\frac{M_r\text{ of desired product}}{\text{sum of }M_r\text{ of all products}}$ x 100 (1)
Examiner's Comments
A significant proportion of candidates left this question blank.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>3</td><td></td></tr>
</table>

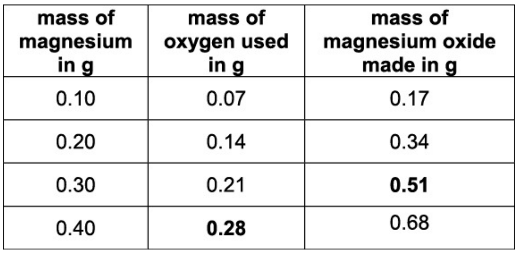
Question			Answer/Indicative content	Marks	Guidance
23			**Level 3 (5-6 marks)** **Candidates correctly calculate the percentage yield and describe some reasons why the yield in this reaction is less than 100%.** Quality of written communication does not impede communication of the science at this level. **Level 2 (3-4 marks)** **Candidates correctly calculate the percentage yield** **OR** **describe some reasons why the yield in this reaction is less than 100%.** Quality of written communication partly impedes communication of the science at this level. **Level 1 (1-2 marks)** **Candidates suggest a reason why the yield is less than 100% in this reaction** **OR** **attempt to calculate the % yield e.g. 3/4.** Quality of written communication impedes communication of the science at this level. **Level 0 (0 marks)** Insufficient or irrelevant science. Answer not worthy of credit.	6	**This question is targeted at grades up to C.** **Indicative scientific points may include:** • percentage yield is 75% • percentage yield = $\frac{actual}{predicted} \times 100$ **reasons why yield is not 100% include:** • loss in filtering solution of magnesium sulfate • some product / solution may bubble over the side of beaker • some solid / solution may be lost in evaporation • loss in transferring solutions / solids • not all reactants react to make product. **Use the L1, L2, L3 annotations in scoris, do not use ticks.** **Examiner's Comments** Many candidates were able to calculate the percentage yield as 75% and score 4 marks.
			Total	**6**	
24			red / pink (1)	1	**Examiner's Comments** The change in colour of phenolphthalein was not well known. Almost all the universal indicator colours were used.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
25		i	all atoms in reactants end up in the product (1)	1	**allow** only hydrogen peroxide is made / only one product made / no waste products / no unwanted products (1) **ignore** no product is wasted **ignore** same number of atoms on each side of the equation / all reactants have been converted into products **Examiner's Comments** Good responses appreciated that the process has 100% atom economy because there are no waste products. Candidates who failed to gain credit gave answers in terms of conservation of mass.
		ii	reduce the production of unwanted **products** / reduces amount of waste **products** (1) makes the process more sustainable (1)	2	reduces waste is **not** sufficient more cost effective / makes more profit is **not** sufficient **allow** makes the process greener (1) **ignore** better for the environment **Examiner's Comments** Good responses explained that high atom economy makes industrial processes more sustainable and reduces waste products. When candidates did not gain credit it was usually because they simply stated that high atom economy reduces waste or stated that there would be less waste reactants.
			Total	**3**	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>26</td><td></td><td></td><td>suitable method of collecting gas – graduated gas syringe, measuring cylinder, burette (2)</td><td>2</td><td>allow one mark for collection using apparatus that was not graduated but the method must work

Examiner's Comments

Many poorly drawn diagrams suggesting that rulers were not used. Many candidates were not familiar with collecting gas over water or in a gas syringe.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>2</td><td></td></tr>
<tr><td>27</td><td>a</td><td></td><td>3rd row – 0.51 (1)

4th row – 0.28 (1)</td><td>2</td><td>
<table>
<tr><th>mass of magnesium in g</th><th>mass of oxygen used in g</th><th>mass of magnesium oxide made in g</th></tr>
<tr><td>0.10</td><td>0.07</td><td>0.17</td></tr>
<tr><td>0.20</td><td>0.14</td><td>0.34</td></tr>
<tr><td>0.30</td><td>0.21</td><td>0.51</td></tr>
<tr><td>0.40</td><td>0.28</td><td>0.68</td></tr>
</table>

Examiner's Comments

These calculations were almost all completed correctly by the candidates.</td></tr>
<tr><td></td><td>b</td><td></td><td>1.0 (g) (1)

1.7g magnesium is 10x 0.17 so amount of Mg is 0.1 x 10 (1)</td><td>2</td><td>allow 1g

explanation must be given for two marks

Examiner's Comments

These calculations were almost all completed correctly by the candidates.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
28		i	$\frac{22.1+22.3+22.2}{3}$ (1) or 22.2 (1)	1	**Examiner's Comments** The average titre was calculated correctly by most candidates. A few incorrectly included 22.9 in the calculation.
		ii	titration 1 is not consistent / only consistently close readings should be included / all the other volumes are close to one another / all the other volumes are within 0.2 cm^3 (1)	1	**allow** titration 1 is a rough titration / titration 1 is inaccurate / it is a practice titration **allow** titration 1 is an outlier or anomaly **allow** it is a very different from the other values e.g. it is (at least) 0.5 cm^3 different **ignore** it does not follow the pattern **Examiner's Comments** Candidates were able to explain why the titration figure 22.9 was ignored in calculating the average.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
29	a	i	idea that 2 g of H_2 makes 34 g of H_2O_2 (1) idea that 100 g of H_2 is 50 × 2 g so mass of H_2O_2 is 34 × 50 (1)	2	**allow** $\frac{34}{2}\times100$ (2) **eg** $H_2 + O_2 \rightarrow H_2O_2$ (1) 2x 50 = 100 34 x 50 = 1700 **allow** 32 × 50 = 1600g O_2 (1) **and** 100g H_2 + 1600g O_2 = 1700g H_2O_2 (1) **but** 100g + 1600g = 1700g scores 0 if no evidence of other relevant calculation **Examiner's Comments** Candidates who understood the idea of reacting masses were able to correctly show that the predicted yield of hydrogen peroxide is 1700g.
		ii	**LOOK FOR ANSWER FIRST OF ALL IF percentage yield = 90 AWARD 2 MARKS** $\frac{1530}{1700}\times100$ (1) 90 (1)	2	**allow** $\frac{actual}{predicted}\times100$ **or** $\frac{am}{pm}\times100$ (1) **Examiner's Comments** Most candidates correctly calculated the percentage yield as 90%.
	b		**LOOK FOR ANSWER FIRST OF ALL IF atom economy = 12.7(34) OR 13 AWARD 2 MARKS** $\frac{34}{169+98}\times100$ **or** $\frac{34}{267}\times100$ **or** $\frac{34}{34+233}\times100$ (1) 12.7 (1)	2	**allow** $\frac{M_r \text{ of desired product}}{\text{sum of } M_r \text{ of all products}}$ x 100 (1) **Examiner's Comments** Responses to this atom economy calculation were better than the similar calculation on the 2014 paper. Incorrect responses usually resulted from 34 divided by 233 (ie the mass of the waste product only) or 34 divided by 534 (ie the mass of the reactants and the products). Incorrect rounding of 12.7%, to give an answer of 12%, was penalised.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
30	a	i	no undesired products made / all the atoms that react end up in the product / only one product made (1)	1	**ignore** no waste is produced but **allow** no waste products **allow** no atoms have been wasted **ignore** all the atoms are used up Many candidates did not understand the concept of atom economy and as a result could not explain what 100% atom economy means. Very few candidates referred to either the formation of just one product or all of the atoms ending up in the desired product. Many candidates just referred to the same number of atoms before and afterwards which does not necessarily mean 100% atom economy. Many candidates did not attempt this question.
		ii	14 (1)	1	unit **not** needed **Examiner's Comments** The answer of 14 tonnes was calculated by some candidates, but others did not attempt the question.
	b		46 % (2) but 46.2 / 46.15 / 46.154 (1)	2	answer must have **two** sig figs for two marks **allow** one mark for $\frac{2.4}{5.2} \times 100$ **Examiner's Comments** Some candidates did not quote their answer to two significant figures and so did not get both marks for the question. The best answers showed the working out and then had the answer correctly rounded to 46% at the end. Some candidates inverted their numbers and obtained a percentage yield above 100%. Other candidates left the question blank.
			Total	**4**	