GCSE Chemistry AQA

Structure and Bonding

Past paper questions booklet

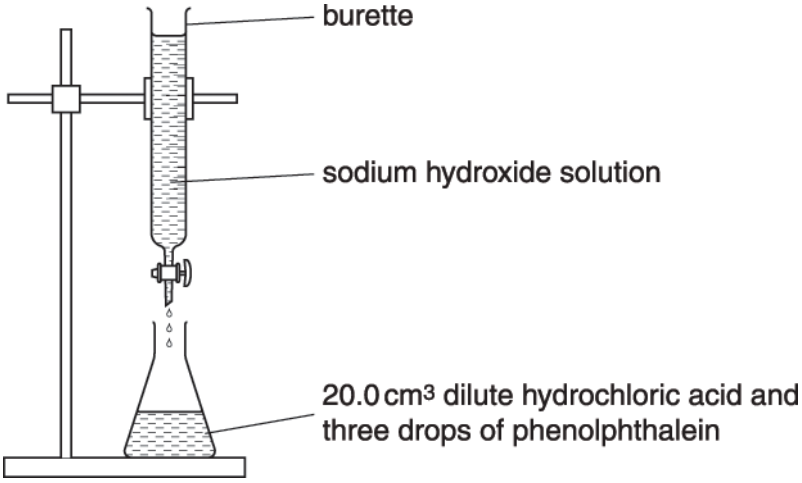
-

1. 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.

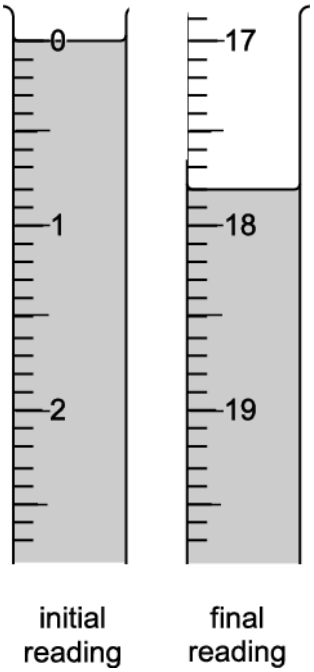
Titration **1** was not included in the calculation of the mean volume of sodium hydroxide added.

Suggest why.

[1]

2. 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.

---

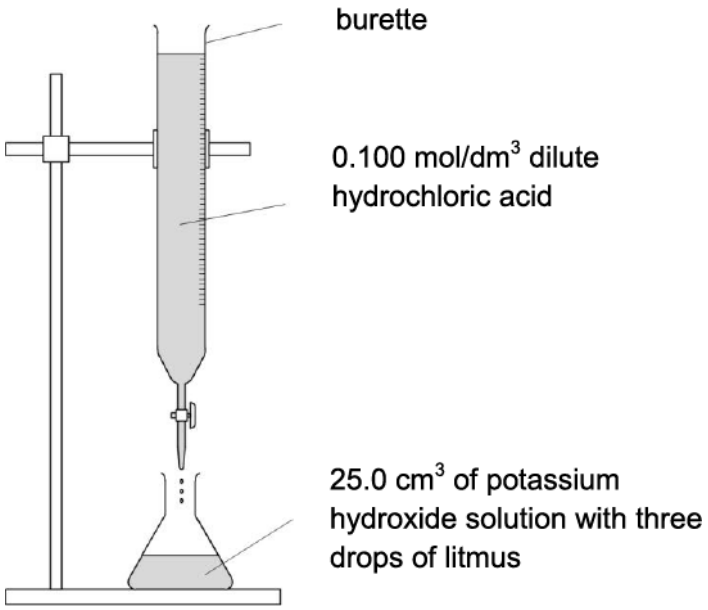
[1]

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

Hydrochloric acid neutralises the alkali potassium hydroxide.

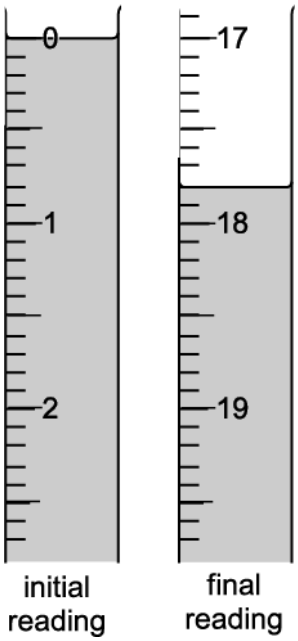
$$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$$

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).

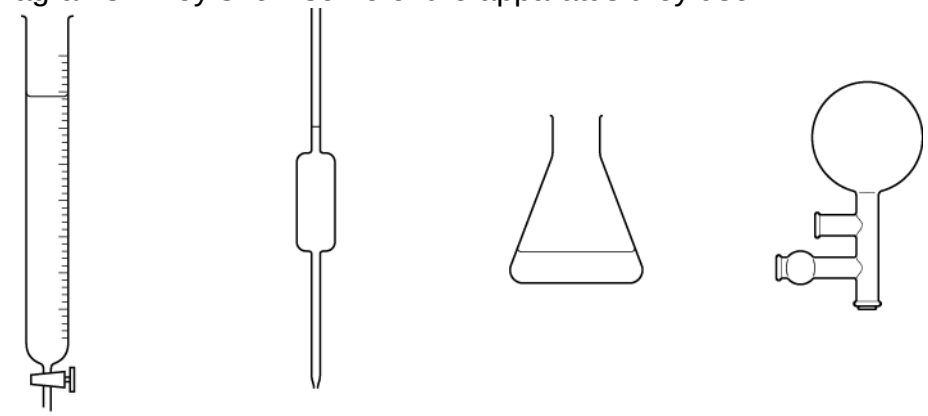
Concentration of KOH(aq) = ... mol/dm^3 **[2]**

(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]**

4. 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.

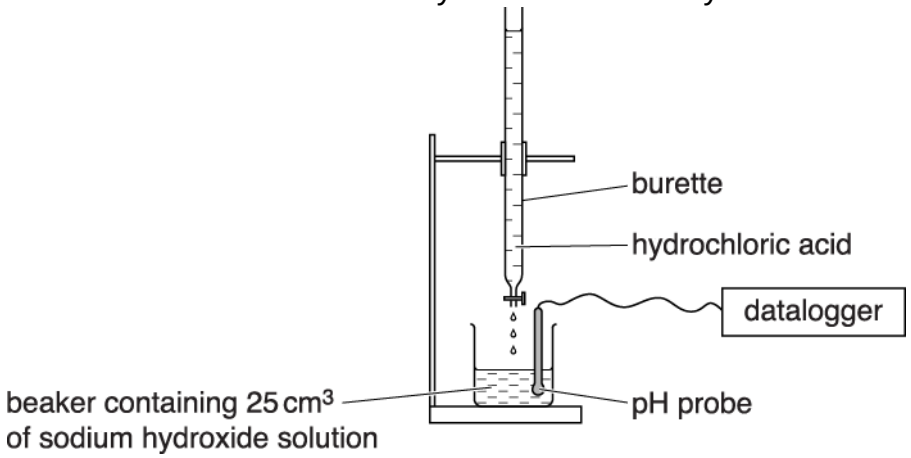
The quality of written communication will be assessed in your answer to this question.

[6]

5. Stewart and Claire want to do a titration.

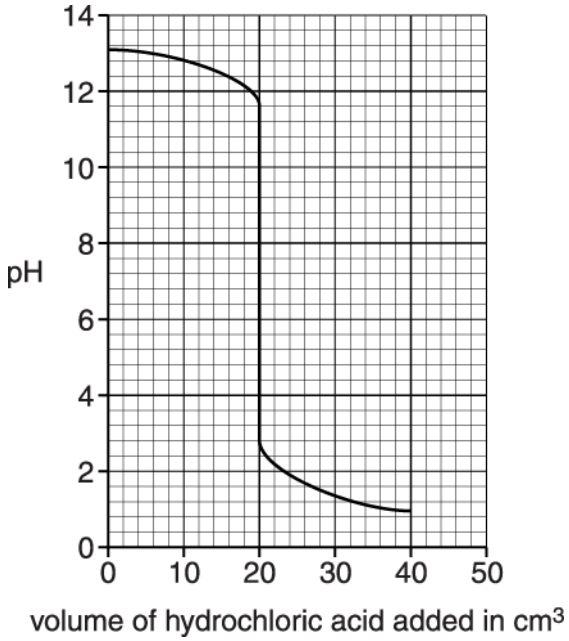
They use a solution of hydrochloric acid with a concentration of 0.10 mol/dm^3.

They titrate 25 cm^3 of a solution of sodium hydroxide with the hydrochloric acid.



They measure the pH of the mixture during the titration.

Look at the graph of their results.



The equation for the reaction is

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

What can you deduce from the graph? Include the volume of hydrochloric acid added at the end-point.

Use the graph to calculate the concentration of the sodium hydroxide solution.

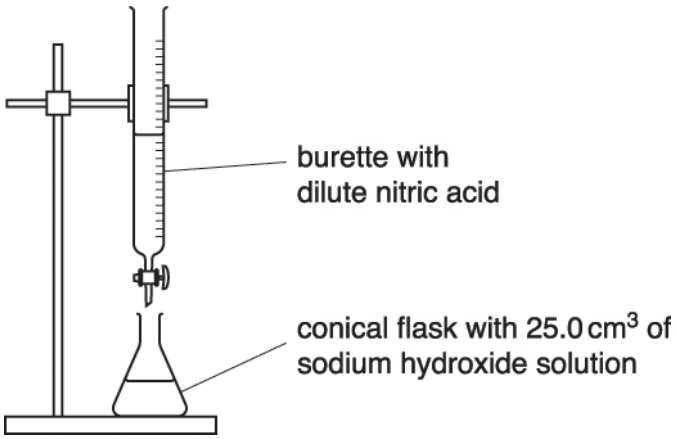
The quality of written communication will be assessed in your answer to this question.

[6]

6. 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]

7(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

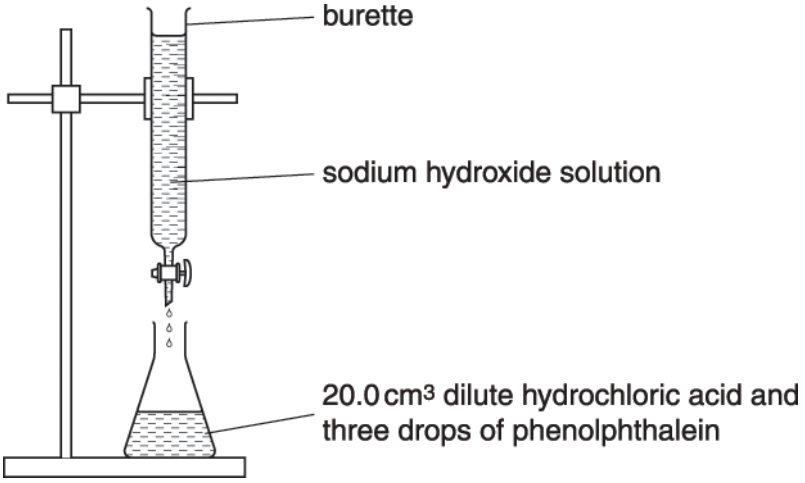
[3]

(b). 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.

Phenolphthalein is a single indicator.

Universal indicator is a mixed indicator.

Explain why Brian used phenolphthalein rather than universal indicator.

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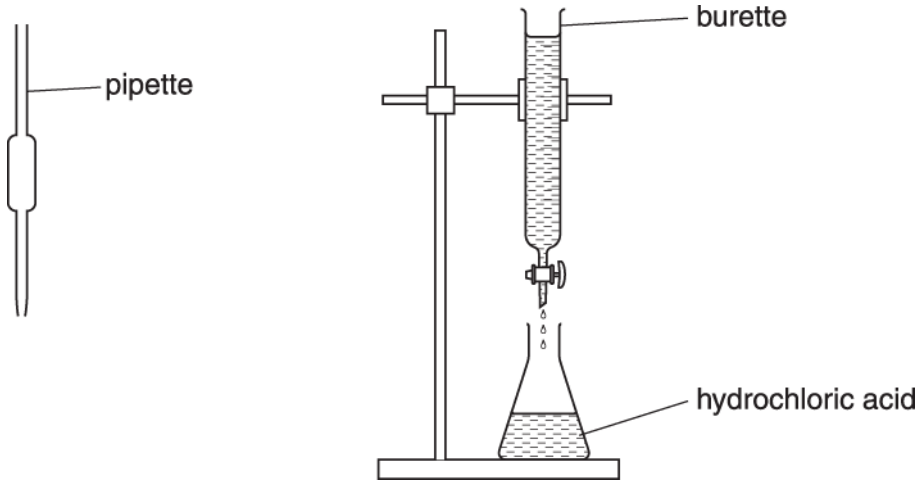
[2]

8(a). 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]

(b). Brian neutralises dilute hydrochloric acid with sodium hydroxide solution.
Brian He does four 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]

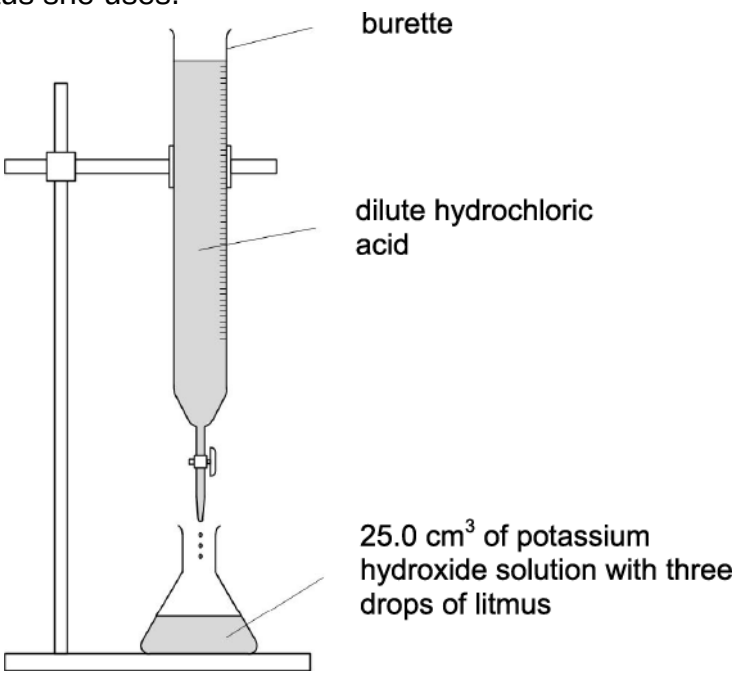
ii. Titration **1** was not included in the calculation of the mean volume of sodium hydroxide added.

Suggest why.

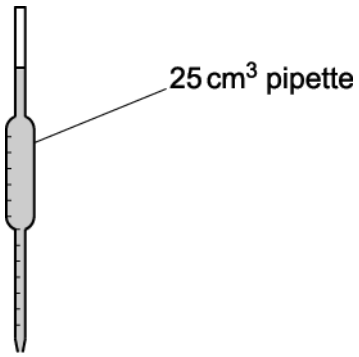
[1]

9(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). 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?

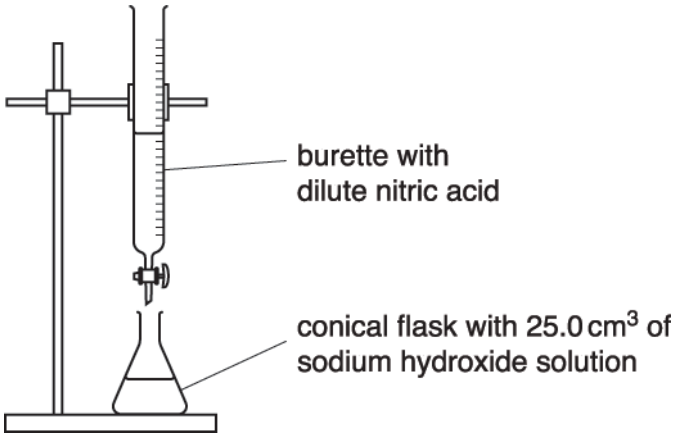
Assume that water is a waste product.

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

10. 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.

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?

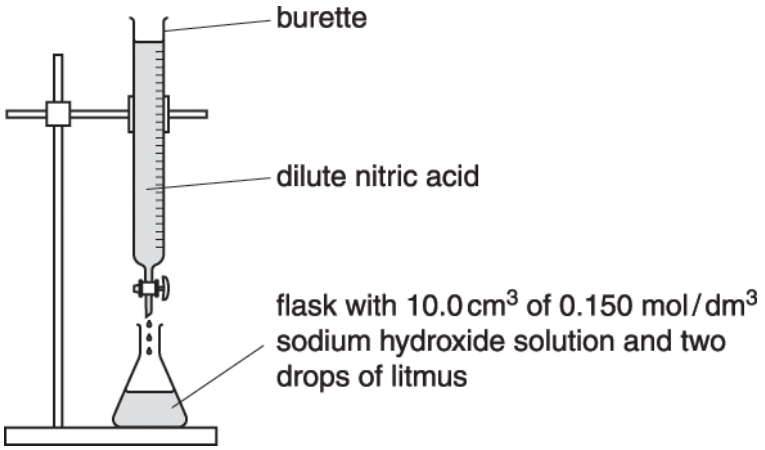
Give your answer to one decimal place.

Average (mean) titre = ... cm^3

[2]

11. 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 four 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.

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]

12. 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]

END OF QUESTION paper

Mark scheme

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Mark s</th><th>Guidance</th></tr>
<tr><td>1</td><td></td><td></td><td>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)</td><td>1</td><td>allow titration 1 is a rough titration / titration 1 is inaccurate / it is a practice titration
allow titre 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 often appreciated that the first titration was a rough one. Other candidates analysed the data and explained that the titre was not consistent with the other titres.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>2</td><td></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></td><td></td><td>Total</td><td>3</td><td></td></tr>
<tr><td>3</td><td>a</td><td></td><td>Mean titre = 17.1 (1)

Because titration 1 is a rough estimate / titration 1 is an outlier / titrations 2 and 3 are identical (1)</td><td>2</td><td>IGNORE anything in the titration table</td></tr>
<tr><td></td><td>b</td><td></td><td>Moles of acid = 0.00171 (1)

Concentration of KOH = 0.0684 (1)</td><td>2</td><td>ALLOW ECF from incorrect titre / 0.100 × titre $\times 10^{-3}$

ALLOW ECF from incorrect moles providing answer is to 3 sig figs / moles÷volume</td></tr>
<tr><td></td><td>c</td><td></td><td>M_r of KOH = 56.1 (1)

Concentration of KOH = 3.84 (1)</td><td>2</td><td>ALLOW correct answer without working

ALLOW 3.837

ALLOW ECF from incorrect M_r and / or incorrect concentration from (b) / M_r × conc</td></tr>
</table>

			Total	**6**	
4			**[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. 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**	
5			**Level 3** **Interprets graph to make at least two deductions one of which correctly identifies end-point** **AND**	6	**This question is targeted at grades up to A / A*.** **Indicative scientific points may include:** **Deductions** • neutralised at or end-point is 20 cm^3 • pH at start, of NaOH, is any value between 12.8 to 13.2

			correctly calculates the concentration of NaOH. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) **Level 2** **Interprets graph to make at least two deductions one of which correctly identifies end-point AND attempts calculation** **OR** **correctly calculates the concentration of NaOH from the wrong end-point.** Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) **Level 1** **Candidate interprets graph to make a simple deduction e.g. volume at end-point.** 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)		• range for rapid rate of change of pH is about 12 to 3 • correctly reads pH for a stated volume of acid • correctly reads volume of acid for a stated pH • strong acid / strong base **Calculation** • no of moles of acid = $\frac{\text{volume}}{1000} \times 0.1$ • no of moles of acid = $\frac{20}{1000} \times 0.1$ or $0.020 \times 10^{-3} = 0.002$ • 25cm^3 of NaOH contains 0.002 moles • concentration of NaOH = $\frac{\text{moles}}{\text{volume}} \times 1000$ or $\frac{\text{moles}}{\text{volume in dm3}}$ • concentration of NaOH = $\frac{0.002}{25} \times 1000$ or $\frac{0.002}{0.025}$ • concentration = 0.08 mol/dm^3 **allow** ecf from incorrect end-point an attempt at a calculation is one of the partial steps in the calculation e.g. working out moles of acid or working out a concentration of NaOH **Use the L1, L2, L3 annotations in Scoris; do not use ticks.** **Examiner's Comments** This six mark question involved the interpretation of a pH titration curve and the calculation of an unknown concentration. Many candidates achieved level 1 by stating one simple deduction from the graph for example 'as the volume of acid is added the pH went down.' Other candidates gave more detailed answers that described what happens to the pH at neutralisation. The term 'end-point' was not well understood and some candidates thought it was the value at the end of the titration rather than at neutralisation. Most candidates either did not attempt the calculation or just wrote down some random numbers. Centres should advise candidates to write down the equation they are using, then substitute in the appropriate numbers and finally do a calculation. Either the use of moles = volume x concentration or concentration = moles/volume was considered an attempt at the calculation. A significant proportion of the candidates who attempted the calculation was not able to convert cm^3 into dm^3 and vice-versa. To get level 3 the calculation had to be complete with a concentration of 0.08 mol/dm^3 or a calculation that had been completed but used the wrong volume (typically 40 cm^3 rather than 20 cm^3) along with one other deduction from the graph.
			Total	**6**	
6			(litmus changes) from blue or purple (1) to red (1)	2	**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

					Examiner's Comments 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.
			Total	**2**	
7	a		**LOOK FOR ANSWER FIRST OF ALL** **IF concentration = 0.08 (mol/dm^3) AWARD 3 MARKS** no of moles in acid = $\frac{20\times0.100}{1000}$ / 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 = $\frac{moles}{0.025}$ / $\frac{moles\times1000}{25}$ **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.
	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**	
8	a		add alkali / sodium hydroxide (from the burette) to acid (1)	3	**allow** or until a colour change is seen **Examiner's Comments**

			(sodium hydroxide is added) until end point is reached (1) add indicator or named indicator (1)		Few candidates scored 3 marks for describing how to complete a titration. A large number did not read the question, and put more hydrochloric acid in the burette, others did not mention an indicator or a colour change.
	b	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	**5**	
9	a		Use a pipette filler (1) Potassium hydroxide is caustic / potassium hydroxide can burn skin (1)	2	
	b		When one drop makes the litmus change colour (1) Correct colour change blue to red (1)	2	**ALLOW** use a pH probe = 1 mark **ALLOW** gives a pH value of 7 when neutral = 1 mark
	c		Atom economy = (M_r of desired products / sum of M_r of all products) × 100 = (101 ÷ 119) × 100 (1) = 84.9 (%) (1)	2	
			Total	**6**	
10		i	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)	2	<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

					Examiner's Comments 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.
		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	**4**	
11		i	idea that average only uses titrations 2, 3 and 4 / titration 1 is not used to calculate the average (1) titrations 2, 3 and 4 have a consistent value / titration 1 is a rough estimate / titration 1 could be an anomalous value / titration 1 is a range-finder / titration 1 is an outlier (1)	2	**allow** calculation of the mean using the values from 2, 3 and 4 **not** just use titration 3 **not** titration 3 is the mid-value **Examiner's Comments** Although many candidates appreciated that titre 1 was an anomaly or an outlier they did not always go on to state that the other three were used to calculate the mean. Only a small proportion of the candidates commented on the closeness of the last three titres. The best answers indicated why titre 1 was not used and then showed how the other three titres are used to get the mean titre. A common misconception was that 25.2 cm^3 was used as a titre because it was the mid-range value of the three best titres.
		ii	0.0015 **or** $1.5 \times 10^{?3}$ (1)	1	**ignore** trailing zeroes **Examiner's Comments** Many candidates could not calculate the amount in moles as 0.0015. The most common misconception was to forget to convert cm^3 into dm^3 and calculate the number of moles as 1.5.
		iii	moles of HNO^3 = 0.0015 **or** $1.5 \times 10^{?3}$ (1) concentration of HNO_3 = 0.0595 (1)	2	**LOOK FOR THE ANSWER FIRST IF IT IS 0.0595 AWARD 2 marks** **allow** ecf from (ii) **allow** one mark for 0.06 / 0.05952 or answers with more significant figures **allow** ecf providing answer has three significant figures i.e. mole/volume **Examiner's Comments** A significant proportion of the candidates did not attempt this question often because they could not do (ii). Only the very best answers showed the working out for the calculation.

					Centres should advise candidates that it is important to show the working out to allow examiner's to award error carried forward marks. Many candidates did not quote the final answer, 0.0595 mol/dm^3, to three significant figures as required in the question and gave the answer as 0.06 mol/dm^3.
			Total	**5**	
1 2			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**	