OCR GCSE GATEWAY CHEMISTRY A · J248

CHEMISTRY



MARK SCHEME

C5.1 MONITORING CHEMICAL REACTIONS

SCORE	PERCENTAGE
/193	%

STEMUP

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<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>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></td><td></td><td>Total</td><td>2</td><td></td></tr>
<tr><td>2</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>3</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>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>c</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>7</td><td></td></tr>
<tr><td>4</td><td></td><td></td><td>Percentage yield =
(actual yield ÷ predicted yield) × 100 or
(2.2 ÷ 4.0) × 100 (1)

55 (1)</td><td>2</td><td>ALLOW full marks for answer with no working out</td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
			Total	2	
5			17 (g) of ammonia makes 66 (g) of ammonium sulfate So 51 g makes 198 g of ammonium sulfate (1)	1	
			Total	1	
6			D	1	
			Total	1	
7			D	1	
			Total	1	
8			C	1	
			Total	1	
9			A	1	
			Total	1	
10	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	

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Question			Answer/Indicative content	Marks	Guidance
11			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	
12		i	Titrate ammonia against sulfuric acid to obtain volumes needed for complete neutralisation (1) Add these volumes without the use of indicator (1) Slow evaporation of reaction mixture / heat reaction mixture over a steam bath (1) Burette and other chemical apparatus not suitable for using large quantities / very difficult to use a steam bath in the large scale (1)	4	ALLOW heat neutral mixture with carbon or charcoal and then filter off carbon ALLOW Slow evaporation of filtrate / heat filtrate over a steam bath if method involving carbon is used
		ii	34 (g or tonnes) of ammonia makes 132.1 (g or tonnes) of ammonium sulfate / 17 (g or tonnes) of ammonia makes 66 (g or tonnes) of ammonium sulfate (1) So 51 tonnes makes 198.1 tonnes of ammonium sulfate (1)	2	ALLOW one mark for correct calculation of M_r for ammonia AND ammonium sulfate IGNORE units for the first marking point ALLOW one mark for 2 moles of ammonia makes 1 mole of ammonium sulfate
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
13			[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

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Question			Answer/Indicative content	Marks	Guidance
					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	

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Question			Answer/Indicative content	Marks	Guidance
14	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 = $\frac{\text{total Mr of desired products}}{\text{total Mr of all products}} \times 100$ (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 = $\frac{\text{actual yield}}{\text{predicted yield}} \times 100$ or percentage yield = $\frac{\text{am}}{\text{pm}} \times 100$ **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.

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Question			Answer/Indicative content	Marks	Guidance
	d	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	8	

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Question			Answer/Indicative content	Marks	Guidance
15	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 = $\frac{60}{60+18} \times 100$ / $\frac{60}{46+32} \times 100$ / $\frac{60}{78} \times 100$ (2)	2	**allow** atom economy formula in words for one mark i.e. atom economy = $\frac{\text{total Mr of desired products}}{\text{total Mr of all products}} \times 100$ (1) or atom economy = $\frac{\text{total Mr of desired products}}{\text{total Mr of all reactants}} \times 100$ (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 = $\frac{9.5}{9.8} \times 100$ (2)	2	**allow** percentage yield formula in words for one mark e.g. percentage yield = $\frac{\text{actual yield}}{\text{predicted yield}} \times 100$ or percentage yield = $\frac{\text{am}}{\text{pm}} \times 100$ **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.

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Question			Answer/Indicative content	Marks	Guidance
	e		has high(er) atom economy / 100% atom economy / less atoms are wasted (1)	1	**allow** reverse argument e.g. process 1 has low(er) atom economy (1) **ignore** references to percentage yield **allow** no or less waste products (1) **ignore** no waste **Examiner's Comments** Almost two thirds of all candidates understood the relationship between a 'green' process and atom economy.
			Total	**7**	
16			**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**	

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>17</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>

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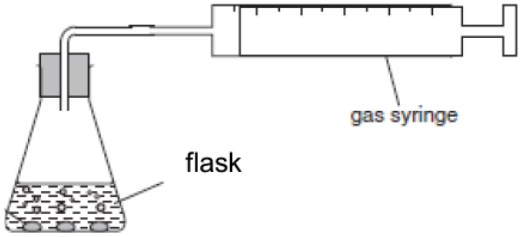
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Question			Answer/Indicative content	Marks	Guidance
		ii	use titrations **2** and **3** / use the last two titrations (1) titre = 18.9 (1)	2	**allow** do not use the rough value (1) **allow** ecf from wrong titres in (i) or from wrong choice of titrations 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	

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Question			Answer/Indicative content	Marks	Guidance
18	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.

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Question			Answer/Indicative content	Marks	Guidance
	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.
		ii	Mass = 0.25 (g) / 2.5 × $10^{?1}$ (1)	1	**allow** ecf from number of moles, i.e. moles × 100 ?Examiner's Comments?? 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**	

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Question			Answer/Indicative content	Marks	Guidance
19	a	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.

Question			Answer/Indicative content	Marks	Guidance
		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.
	b		does not give a sudden **colour** change / **colour** changes slowly / continually changes **colour** / (1)	1	**allow ora** if specified **allow** universal indicator is a mixed indicator / universal indicator is made up of different components / universal indicator has a range of colours **allow** universal indicator gives the pH rather than the end-point **Examiner's Comments** Many candidates appreciated that universal indicator showed many colours or had a gradual colour change. Some candidates did not mention the word colour in their answer and only referred to a slow change. This was not sufficient to be awarded a mark. Only a small proportion of the candidates appreciated that universal indicator was a mixed rather than a single indicator.

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Question			Answer/Indicative content	Marks	Guidance
			Total	6	

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Question			Answer/Indicative content	Marks	Guidance
20	a		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** 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.

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Question			Answer/Indicative content	Marks	Guidance
	b		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.

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Question			Answer/Indicative content	Marks	Guidance
	c		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	6	

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Question			Answer/Indicative content	Marks	Guidance
21	a	i	68 (cm^3) (1)	1	**Examiner's Comments** Candidates were often able to interpret the graph and get a volume of 68 cm^3, although some candidates misread the scale and got 64 cm^3.
		ii	37–39 (seconds) (1)	1	**Examiner's Comments** Candidates were often able to interpret the graph and appreciated that the reaction finished somewhere between 37 and 39 seconds.
		iii	line needs to level off at same height and be steeper initially (1)	1	By eye the line should go through the origin Line drawn to left of original and must not go above 79 cm^3 at any point but must end at 78 cm^3 **Examiner's Comments** Some candidates missed out this question. Other candidates gave a final volume greater than 68 cm^3 which is incorrect but a significant proportion were able to sketch the correct curve.
	b		reactant not in excess / that is all used up (at the end of the reaction (1)	1	**allow** reactant that determines the volume of hydrogen given off (1) **allow** substance that causes the reaction to stop **allow** reagent that runs out (first) **Examiner's Comments** The concept of a limiting reagent was well understood and many candidates gave their answer in the context of the actual experiment described i.e. magnesium was a limiting reagent since when it runs out the reaction stops.
			Total	4	

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>22</td><td>a</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>b</td><td>i</td><td>burette (1)</td><td>1</td><td>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’.</td></tr>
<tr><td></td><td></td><td>ii</td><td>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)</td><td>2</td><td>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.</td></tr>
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Question			Answer/Indicative content	Marks	Guidance
		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.
			Total	**7**	

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Question			Answer/Indicative content	Marks	Guidance
23	a		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.
	b	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	$\frac{(2\times 60)}{(2\times 60)+142}\times 100$ **or** $\frac{120}{262}\times 100$ **or** $\frac{(2\times 60)}{(2\times 82)+98}\times 100$ **or** $\frac{120}{164+98}\times 100$ (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.

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Question			Answer/Indicative content	Marks	Guidance
	c	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 $\frac{2.4}{5.2} \times 100$ **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	8	

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Question			Answer/Indicative content	Marks	Guidance
24			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 possible, although marks scored in this

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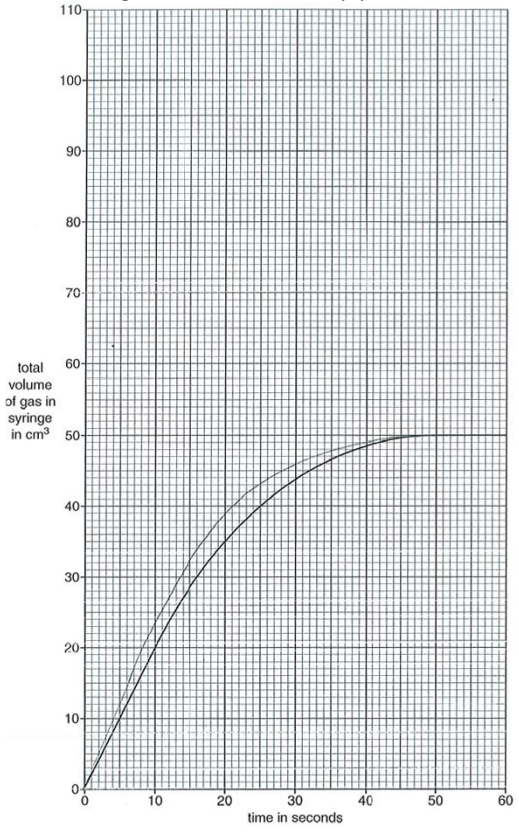
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Question			Answer/Indicative content	Marks	Guidance
					way were again rarer. As in the other 6 mark questions on the paper, candidates had to address all aspects of the question to gain credit at level 3 (5-6 marks). Many candidates did not explain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

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Question			Answer/Indicative content	Marks	Guidance
25		i	47–51 (seconds) (1)	1	Examiner's Comments Most candidates were able to interpret the graph to determine how long it takes the reaction to stop.
		ii	2 (cm^3/s) (1)	1	**allow** 120 cm^3/min (1) Examiner's Comments The rate of the reaction was usually correctly calculated from the graph.
		iii	Please see suggested answer on page 15 line drawn to left of original and passing through the origin (1) line ending at same volume (1)  	2	**allow** line drawn to left of original but ending above or below 50 cm^3 (1) **allow** line drawn to right of original but ending at 50 cm^3 (1) Examiner's Comments Good responses showed a curve drawn to the left of the original passing through the origin, with the second mark awarded for a line ending at the same volume as the original. It was the second mark that about a quarter of candidates failed to score.
			Total	4	

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Question			Answer/Indicative content	Marks	Guidance
26		i	98 (1)	1	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%.
		ii	LOOK FOR ANSWER FIRST OF ALL IF atom economy = 12.7(34) OR 13 AWARD 2 MARKS $\frac{34}{169+98}\times 100$ **or** $\frac{34}{267}\times 100$ **or** $\frac{34}{34+233}\times 100$ (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 A significant proportion of candidates left this question blank.
			Total	3	
27	a		$CuCO_3$? $CuO + CO_2$ (1)	1	**allow** = for ? **not** and or & for + **allow** any correct multiples Examiner's Comments The balanced symbol equation was correctly written down by a number of candidates. A number reversed the equation and put copper carbonate as the product scoring no marks.
	b	i	4.40 g (1)	1	Examiner's Comments Was well answered.
		ii	8.80 g (1)	1	**allow** ecf from part (i) ie 2 × answer (i) Examiner's Comments Required a deeper understanding of the figures and was found to be a difficult calculation.
			Total	3	

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Question			Answer/Indicative content	Marks	Guidance
28			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% • $\text{percentage yield} = \frac{actual}{predicted} \times 100$ 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	

Question			Answer/Indicative content	Marks	Guidance
29	a		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.
	b		add alkali / sodium hydroxide (from the burette) to acid (1) (sodium hydroxide is added) until end point is reached (1) add indicator or named indicator (1)	3	**allow** or until a colour change is seen Examiner's Comments 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.
	c	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	6	

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>30</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>
<tr><td>31</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>32</td><td></td><td></td><td>yes as the temperature increases the mass decreases / no because from 500 the mass no longer decreases (1)

idea that the lower the mass the more carbon dioxide is made / correct link between decrease in mass and the mass of carbon dioxide being made (1)</td><td>2</td><td>no mark for yes or no on its own

Examiner's Comments

Most candidates were able to interpret the data correctly to score 1 mark with some correctly linking the fall in mass to the gas being given off, for 2 marks.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>2</td><td></td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
33	a	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.

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Question			Answer/Indicative content	Marks	Guidance
	b	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 $\frac{34}{2} \times 100$ (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 $\frac{1530}{1700} \times 100$ (1) 90 (1)	2	allow $\frac{actual}{predicted} \times 100$ **or** $\frac{am}{pm} \times 100$ (1) Examiner's Comments Most candidates correctly calculated the percentage yield as 90%.
	c		LOOK FOR ANSWER FIRST OF ALL IF atom economy = 12.7(34) OR 13 AWARD 2 MARKS $\frac{34}{169+98} \times 100$ **or** $\frac{34}{267} \times 100$ **or** $\frac{34}{34+233} \times 100$ (1) 12.7 (1)	2	allow $\frac{M_r \text{ of desired product}}{\text{sum of } M_r \text{ of all products}} \times 100$ (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	9	

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Question			Answer/Indicative content	Marks	Guidance
34	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**	

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Question			Answer/Indicative content	Marks	Guidance
35			B ✓	1(AO 1.1)	Examiner's Comments By contrast, atom economy was much less well understood. Candidates clearly realised that it is a measure of the desired products and so almost no-one chose option A with its heavy emphasis on the waste products. However, the choices between options B, C and D were fairly evenly spread at all ability ranges.
			Total	1	
36			A ✓	1(AO 1.1)	
			Total	1	
37			A ✓	1(AO 1.2)	
			Total	1	

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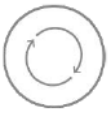
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Question			Answer/Indicative content	Marks	Guidance
38	a		FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 2.24 / 2.243 / 2.2 (dm^3) award 2 marks** Moles of ammonium chloride = 5.00 ÷ 53.5 or 0.0935 ✓ Volume of ammonia = moles × 24 = 0.0935 × 24 = 2.24 / 2.243 / 2.2 (dm^3) ✓ OR 2 × 53.5 = 107g ammonium chloride produces 2 × 24 = 48 dm^3 ammonia ✓ So 5.00g of ammonium chloride produces $\frac{5 \times 2 \times 24}{2 \times 53.5}$ = 2.24 / 2.243 / 2.2 (dm^3) ammonia ✓	2(AO 2.2)	**ALLOW** 0.09 / 0.094 **ALLOW ECF** from moles of ammonium chloride **if first mark not awarded** **ALLOW** 2.16 (ECF from 0.09) Examiner's Comments Higher ability candidates correctly calculated the volume of ammonia gas as 2.24dm³. Examiners gave error carried forward for correctly converting an incorrectly calculated number of moles to a volume. Common errors in this calculation included • using 107 (2 × 53.5) as the formula mass before calculating the number of moles of NH_4Cl to give an answer of 1.12 • just multiplying 5(g) × 24 • dividing the number of moles by 24 • converting 24dm³ to cm³ before multiplying by the number of moles

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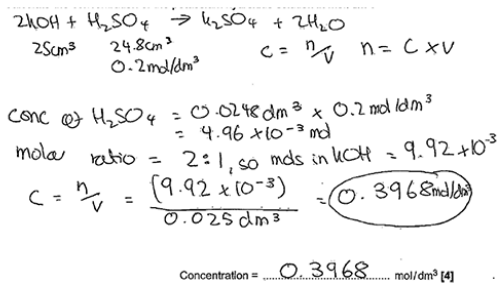
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Question			Answer/Indicative content	Marks	Guidance
	b		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.3968 / 0.397 / 0.40 (mol / dm^3) award 4 marks Moles of acid = $\frac{0.200 \times 24.80}{1000}$ or 0.00496 / 4.96×10^{-3} ✓ Moles of KOH = 2 × 0.00496 or 0.00992 / 9.92×10^{-3} ✓ Concentration of KOH = $\frac{0.00992}{25.0} \times 1000$ ✓ = 0.3968 / 0.397 / 0.40 (mol / dm^3) ✓	4(AO 2.2)	ALLOW 0.005 / 5.00×10^{-3} ALLOW clear indication that the ratio of KOH:acid is 2:1 ALLOW 0.01 / 1.00×10^{-2} ALLOW ecf from incorrect moles of acid ie 2 × moles of acid ALLOW ecf from incorrect moles of KOH eg $\frac{0.00496}{25.0} \times 1000 = 0.1984$ ie 0.1984 would **score 3 marks** Examiner's Comments Some of the responses were excellent, with clearly shown working out that was easy for the examiner to follow. If candidates did not obtain an answer of 0.3968 mol / dm^3 examiners looked to award marks for working out and / or ECF. It is worth centres stressing to candidates that this is only possible when an answer is clearly set out. The most common error was ignoring the stoichiometry of the reaction.  AfL Many candidates still forget to convert cm^3 to dm^3 before calculating moles or concentrations.

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Question			Answer/Indicative content	Marks	Guidance
					Exemplar 5  $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$ 25cm³ 24.8cm³ 0.2mol/dm³ $c = \frac{n}{V}$ $n = c \times v$ conc of H_2SO_4 = 0.0248 dm³ x 0.2 mol/dm³ = 4.96×10^{-3} mol molar ratio = 2:1, so mols in KOH = 9.92×10^{-3} $c = \frac{n}{V} = \frac{(9.92 \times 10^{-3})}{0.025\ dm^3} = 0.3968$ mol/dm³ Concentration = 0.3968 mol/dm³ [4] This response illustrates a clearly set out calculation answer, which is easy for the examiner to follow. When candidates write numbers at random in the answer space it is difficult for the examiner to seek out credit-worthy points and / or award marks for errors carried forward.
	c	i	Moles of acid/HC*l* = 35.0 ÷ 1000 × 000.075 = 0.002625 / 0.0026 / 2.625 × 10^{-3} / 2.6 × 10^{-3} ✓ Moles of alkali / NaOH = 25.0 ÷ 1000 × 0.100 = 0.0025 / 2.5 × 10^{-3} ✓ The acid is in excess ✓	3(AO 2.2)	**ALLOW** 1 mark for moles of acid = 2.625 **and** moles of alkali = 2.5 (ie use of cm^3 instead of dm^3) **Third mark dependent on clear attempt at a calculation of moles of acid and alkali** **ALLOW ECF** from calculated moles of acid and alkali <u>Examiner's Comments</u> Many candidates correctly calculated the moles of HC*l* and NaOH and deduced that the HC*l* is in excess. AfL Many candidates still forget to convert cm³ to dm³ before calculating moles or concentrations – see also Question 22(c).

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Question			Answer/Indicative content	Marks	Guidance
		ii	Correct choice of concordant results – 36.3 and 36.2 ✓ Mean = (36.30 + 36.20) ÷ 2 = 36.25 (cm^3) ✓	2(AO 2.2)	ALLOW 1 mark for ECF from any incorrect choice of concordant values eg 35.875 / 35.88 / 35.9 (cm^3) if all values are used Examiner's Comments Many candidates correctly selected the concordant results from titrations 1 & 4 to calculate the mean volume as 36.25 cm^3. Lower ability candidates tended to calculate the mean from all four titres; 1 mark was given.
			Total	11	
39			D ✓	1 (AO2.2)	
			Total	1	

Question			Answer/Indicative content	Marks	Guidance
40	a		(acid + alkali →) **salt** ✓ + **water** ✓	2 (AO1.2)	**ALLOW** answers in either order
	b		**Any one from:** Use a single indicator / named single indicator eg methyl orange / phenolphthalein (instead of universal indicator)✓ Idea that universal does not give a sudden colour change / universal indicator gives a continuous colour change / ORA ✓ OR Fill the burette exactly to the 0.0 cm^3 line ✓ Idea that this will give accurate volume of acid ✓ OR Idea of adding acid to the alkali **slowly or dropwise** near the end point ✓ As indicator should change colour on addition of one drop (of acid) ✓ OR Idea of swirling the alkali while adding the acid ✓ To ensure mixing of acid and alkali ✓ OR Use a white tile under the conical flask ✓ To see the colour change easily / clearly ✓	2 (AO3.3b)	**Explanation must be linked to reason** **ALLOW** idea of using a pH probe or pH meter
	c		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 23.65 (cm^3) award 2 marks** Use of volume of acid from only titrations 2 & 3 / Use of only 23.60 & 23.70 ✓ Accurate volume of acid = 23.65 (cm^3) ✓	2 (AO2.2)	**ALLOW** 1 mark for average calculated using all results, ie 24.35 (cm^3)
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
41		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 120 (tonnes) award 3 marks M_r of NH_3 = 17 **AND** M_r of NH_4NO_3 = 80 ✓ Mass of ammonium nitrate = $\frac{80}{17}$ x 25.5 / 1.5 x 80 ✓ = 120 (tonnes) ✓	3 (AO2.1)	**ALLOW** ECF from incorrect RMMs
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 10(g) award 2 marks Actual mass = $\frac{80 \times 12.5}{100}$ ✓ = 10 (g) ✓	2 (AO1.2) (AO2.2)	**ALLOW** % yield = (am ÷ pm) x 100 **OR** 80 = (am ÷ 12.5) x 100 for 1 mark if no other mark awarded
			Total	5	
42			D ✓	1 (AO2.2)	
			Total	1	
43			B ✓	1 (AO2.2)	
			Total	1	
44			D ✓	1 (AO1.1)	
			Total	1	
45			C ✓	1 (AO1.1)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
46		i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 120 (tonnes) award 3 marks M_r of NH_3 = 17 **AND** M_r of NH_4NO_3 = 80 ✓ Mass of ammonium nitrate = $\frac{80}{17}$ × 25.5 / 1.5 × 80 ✓ = 120 (tonnes) ✓	3 (AO2.1)	**ALLOW** ECF from incorrect RMMs
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 10(g) award 2 marks Actual mass $= \frac{80 \times 12.5}{100}$ ✓ = 10 (g) ✓	2 (AO1.2) (AO2.2)	**ALLOW** % yield = (am ÷ pm) × 100 **OR** 80 = (am ÷ 12.5) × 100 for 1 mark if no other mark awarded
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
47	a		**Any one from:** Use a single indicator / named single indicator eg methyl orange / phenolphthalein (instead of universal indicator)✓ Idea that universal indicator does not give a sudden colour change / universal indicator gives a continuous colour change / ORA ✓ **OR** Fill the burette exactly to the 0.00 cm^3 line ✓ Idea that this will give accurate volume of acid ✓ **OR** Idea of adding acid to the alkali <u>slowly</u> **or** <u>dropwise</u> (near the end point) ✓ Idea that indicator should change colour on addition of one drop (of acid) ✓ **OR** Idea of swirling the alkali while adding the acid ✓ To ensure mixing of acid and alkali / AW ✓ **OR** Use a white tile under the conical flask ✓ To see the colour change easily / clearly ✓ **OR** Repeat the experiment <u>until concordant or consistent results are obtained</u> ✓ To obtain a more accurate titre / AW ✓ **OR** Idea of doing a rough titration ✓ As this will give you an idea of the endpoint ✓	2 (AO3.3b)	**Explanation must be linked to improvement** **ALLOW** idea of using a pH probe or pH meter to give a more accurate indication of when neutralisation occurs **ALLOW** idea of missing the end point **ALLOW** two improvements, with no explanation, for 1 mark if no explanations given

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Question			Answer/Indicative content	Marks	Guidance
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 23.65 (cm^3) award 2 marks** Use of volume of acid from titrations 2, 3 & 4 / Use of 23.60, 23.70 & 23.65 ✓ Accurate volume of acid = 23.65 (cm^3) ✓	2 (AO2.2)	**DO NOT ALLOW** 23.7 (cm^3) **ALLOW** 1 mark for average calculated using all results, ie 24.18 / 24.175 (cm^3) but **DO NOT ALLOW** 24.2 (cm^3)
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 0.106 (mol / dm^3) award 4 marks** moles of alkali $= \frac{0.200 \times 25.0}{1000}$ / 0.200 x 0.0250 / moles of acid = $\frac{0.005}{2}$ = 0.0025 / 2.5×10^{-3} ✓ $= \frac{0.0025}{0.02365}$ / $\frac{0.0025 \times 1000}{23.65}$ / $\frac{2.5 \times 10^{-3}}{0.02365}$ / $\frac{2.5 \times 10^{-3} \times 1000}{23.65}$ / 0.1057 (mol/dm^3) ✓ concentration = 0.106 (mol / dm^3) (3 sig. figs) ✓	4 (AO3 × 2.2) (AO1.2)	**ALLOW** ECF from moles of alkali **ALLOW** ECF from average titre in **(i)** **ALLOW** ECF from moles of acid i.e. conc = $\frac{\text{moles}}{0.02365}$ or $\frac{\text{moles} \times 1000}{23.65}$
			Total	8	

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Question			Answer/Indicative content	Marks	Guidance
48	a	i	FIRST CHECK THE ANSWER ON ANSWER LINE **If answer = 0.00125 / 1.25×10^{-3} award 2 marks** Moles = $\frac{\text{volume}}{24}$ / $\frac{0.030}{24}$ / $\frac{30}{24{,}000}$ ✓ = 0.00125 / 1.25×10^{-3} ✓	2 (AO2.2)	**ALLOW** 1 mark only for 30 ÷ 24 or 0.030 ÷ 24,000, correctly calculated
		ii	0.0025 / 2.5×10^{-3} (g) ✓	1 (AO2.2)	**unit not needed** **ALLOW** ECF from **(i)** ie 2 x answer from **(i)**
	b		Moles of chromium = $\frac{10.40}{52.0}$ = 0.2 ✓ Moles of nickel = $\frac{17.61}{58.7}$ = 0.3 ✓ Idea that ratio is 2:3 / ratio isn't 1:1 so <u>equation 2</u> ✓	3 (AO2.2)	**ALLOW** other methods of calculation eg 10.40g of chromium forms $\frac{10.40}{52.0} \times 58.7$ = 11.74g nickel $\frac{11.74}{3} \times 2 = 17.61\text{g}$ of nickel So, equation 2 **ALLOW** answers that show equation 1 is not correct **Third marking point is dependent on correct mathematical reasoning**
			Total	**6**	

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