Mark Scheme

Q1.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	• calculation of moles of magnesium	Example of calculation: (n= 0.04 ÷ 24.3 =) 0.001646 (mol) Allow 0.04 ÷ 24 = 0.001667 (mol) Ignore significant figures except 1	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	• calculation of moles of hydrogen	Answer to (a)(i)	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(iii)	• temperature changed to Kelvin (1) • rearrangement of equation so $V=nRT \div p$ and substituting the numbers (1) • calculation of V in m^3 / dm^3 (1) • answer converted in cm^3 and to a whole number (1)	Example of calculation: 24°C = 297 K $V = \frac{0.001646 \times 8.31 \times 297}{101000}$ $= 4.022 \times 10^{-5}$ (m^3) $= 4.022 \times 10^{-5} \times 10^{6} = 40$ cm^3	(4)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	An answer that making reference to any of the following: • To identify anomalies **and** discard • To identify random errors **and** discard • Identify precise results **and** use them • Identify imprecise results **and** discard them	Allow To improve reliability/ reproducibility Ignore reference to confidence in the results Ignore 'make results more precise' Do not award "to improve accuracy"	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	An answer that makes reference to three of the following linked pairs: • **issue:** hydrogen escapes from the apparatus (1) • **improvement:** use a sealed apparatus with a gas syringe /use a conical flask / bung with a gas syringe (1) • **issue:** magnesium ribbon covered with oxide (1) • **improvement:** clean with abrasive before weighing (1) • **issue**: mass of magnesium may be less than 0.04 g (i.e. as low as 0.035 g) **or** mass of magnesium required is too small to be measured accurately by the balance available (1) • **improvement:** use more precise balance/ use larger mass (so percentage error is less) (1) • **issue:** large measuring cylinder cannot measure volume accurately (as the graduations are too far apart) (1) • **improvement:** use a smaller measuring cylinder/burette/ conical flask / bung with a gas syringe (1)	Maximum **three** marks for issues identified Maximum **three** marks for improvement identified which must be linked with associated issue identified or near-miss Do not award impurities in magnesium Allow measurement uncertainty for measurement accuracy If more than three issues are given, then maximum 4 marks if incorrect chemistry is stated e.g. reference to 'not all the magnesium reacting' Ignore reference to: The solubility of hydrogen gas Changes in temperature Changes in acid concentration Air already in the apparatus Measuring the length of Mg	(6)

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to one of the following points: • the colour of the pineapple juice masks the colour change **or** methyl orange only works with a strong acid **or** methyl orange does not change colour in the vertical section of the titration curve	Allow methyl orange is a similar colour to pineapple juice Accept methyl orange cannot be used with a weak acid (and strong alkali) Allow the pH range / 3.2-4.4 / pK_{in} of methyl orange is below the equivalence point / too low Allow the colour change would occur before the equivalence point / is not over the equivalence point Allow the pH at the equivalence point is not in the pH range of methyl orange Allow end point for equivalence point Ignore just 'no colour change observed' Ignore just 'end point is not accurate'	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • the titre value would be greater (than expected) **(1)** • as the titre value includes the volume of the air bubble (as well as sodium hydroxide solution) **(1)**	M2 conditional on M1 scored Allow some alkali / solution is used to fill the air bubble / jet Allow there is less sodium hydroxide in the burette than expected	(2)

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	an answer that makes reference to the following point: volume/space occupied by one mole of a gas at a specified temperature and pressure/rtp/stp/standard conditions	temp and pressure need not be s.t.p. or r.t.p. ignore just reference to 22.4 or 24 dm^3 Ignore units of volume, if given.	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	(% volume uncertainty =)1% **(1)** (% mass uncertainty =) 1/1.1/1.09/1.08696 % **(1)**	example of calculation 0.5 cm^3 in 50 cm^3 % uncertainty = $\frac{0.5}{50}$ x 100 = 1% mass of gas = 107.655 – 107.563 = 0.092 g uncertainty = 0.0005 x 2 0.001 g in 0.092 g % uncertainty = $\frac{0.001}{0.092}$ x 100 = 1/1.1/1.09/1.08696 % Ignore uncertainties added together Do not award calculation of uncertainty in each mass reading (often added together +1) eg 0.0004644 + 0.0004648 + 1 = 1.000928	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	an answer that makes reference to the following points: halves the % volume uncertainty /0.5 cm^3 in 100 cm^3 = 0.5% **(1)** (volume of gas is doubled so mass of gas doubles), % mass uncertainty (also) halves. **(1)**	 TE for answer to (b)(i) ÷ 2 TE for answer to (b)(i) ÷ 2 Allow 1 mark for both uncertainties decrease	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iii)	• mass of gas and expression for molar mass **(1)** • molar mass to 2 or 3 SF and correct units **(1)**	example of calculation mass of gas = 107.655 – 107.563 = 0.092 g and molar mass = 0.092 x 24000 /50 = 44.16 Allow any other correct alternative calculation TE from M1 to M2 for incorrect mass only 44.2/44 **g mol^{-1}** Correct answer to 2/3 SF with/without working gets 2 marks	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iv)	an explanation that makes reference to the following points: • plunger does not return (to zero/original position) when released **(1)** • molar mass will decrease **because** 'air' has a lower molar mass (than 44/carbon dioxide) **(1)**	Mark independently There must be some reference to air	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	An answer that makes reference to the following points: • the calculated molar mass would be greater **(1)** • at a lower temperature there would be more molecules/moles/mass in the same volume /density is greater. **(1)**	Points to be marked independently Standalone mark Do not award for answers that refer to smaller volume Ignore smaller molar volume Ignore particles/molecules/atoms closer together	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d)	an answer that makes reference to the following point: water (vapour) would decrease/affect molar mass OR gas is now a mixture so would decrease/affect molar mass	Ignore gas may dissolve in water Do not award water may react with gas in syringe Do not award wet gas is heavier Ignore answers that refer to molar volume	**(1)**

Q4.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	• 1.60 **(1)** • (+) 42.5 **(1)**	Do not award MP1 for "1.6" (must be to 2 D.P.) Do not award MP2 for "42.50" (must be to 1 D.P.) Penalise D.P. error once only	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	$CH_3OH(l) + 1.5O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ • Balanced equation (1) • State symbols all correct (1)	 Do not award multiples (enthalpy change is for the complete combustion of one mole) for MP1 MP2 depends on the award of MP1 or correct species	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	• Calculation of energy change (1) • Calculation of moles of CH_3OH (1) • Calculation of energy ÷ moles CH_3OH (1) • ΔH final answer in kJ mol^{-1} **and** negative sign included **and** ΔH final answer to 2 or 3 S.F. (1)	Example of calculation (= mcΔT = 150 x 4.18 x 42.5 =) 26647.5 (J) Moles CH_3OH = 1.60/32 (= 0.05(00)) $\frac{26647.5}{0.05(00)}$ = 532950 (J mol^{-1}) Ignore any signs at this stage −533 (kJ mol^{-1}) **Or** −530 (kJ mol^{-1}) Correct answer with no working gains full marks Penalise incorrect units for MP4 only Allow TE at each stage Allow correct rounding to 2SF or more at each stage	(4)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	(±)0.7 (%)	Allow from 1 SF up to calculator value correctly rounded where (% uncertainty =) (±) $\frac{1}{150}$ x 100 = 0.66666...7 (%) Allow 0.6 or $\frac{2}{3}$ Do not award 0.66/0.6	(1)

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Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points: • Calculation of the % uncertainty using the 25 cm^3 measuring cylinder **(1)** **Then any two from:** • % uncertainty with use of 25 cm^3 measuring cylinder is greater **(1)** • Repeated use of the small measuring cylinder will lead to greater transfer losses **(1)** • Repeated use will take more time **(1)**	Needs to show combined error in using the 25 cm^3 six times is greater than using 250 cm^3 measuring cylinder once only Award MP1 EITHER if multiplies errors: 100 x (0.2 /25) x 6 = 4.8% OR If adds errors 100 x (1.2 /150) = 0.8% Do not award (0.2 / 25) x 100 = 0.8 % Do not award 'easier' to use larger measuring cylinder	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(iii)	An answer that makes reference to any **three** of the following points: • heat/energy loss (to the surroundings) **(1)** • evaporation of methanol / water from the calorimeter **(1)** • incomplete combustion (of methanol) **(1)** • (specific) heat capacity of the calorimeter/apparatus has been ignored **(1)**	Ignore experiment carried out under non-standard conditions Ignore just 'no lid' Allow calorimeter has not been calibrated	(3)

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Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	An explanation that makes reference to the following points: • The second value will be less exothermic / less negative **(1)** • Some energy will be used to boil the water/boiling water is endothermic Water can only be heated to 100°C/ Temperature rise (measured) can only be (a maximum) of 40°C Greater heat losses in the 60°C to 100°C range **(1)**	Allow 'more positive' or 'smaller in magnitude' Do not accept 'greater' or 'smaller' for 'less negative' Do not award **just** "the water boils" Mark points M1 and M2 independently	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)	An explanation that makes reference to the following points: Either • student 2's value will be similar / the same **(1)** • (As) both the energy change **and** moles/mass (of methanol) burned will be higher/ Ratio of energy change to moles/mass (of methanol) burned will be the same/ The energy change is proportional to the moles/mass (of methanol) burned **(1)** Or • student 2's value will be less negative/ less exothermic **(1)** • greater heat loss because higher temperature/heated for longer **(1)**	Allow 'temperature change' for 'energy change' Allow 'more positive' or 'smaller in magnitude' or 'smaller' for 'less negative' Mark points MP1 and MP2 independently within each route	(2)

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Question Number	Acceptable Answers	Additional Guidance	Mark
(g)	An answer that makes reference to the following points: • (Calculated) value of moles (of methanol) burned will be less / too small **(1)** • The calculated value will be more exothermic / more negative **(1)**	 Allow **both** marks for a calculation using M_r of 46.0 (instead of 32.0), giving a final ΔH value (approx.) of −766 (kJ mol^{-1}) Allow 'increase' or 'greater' for 'more negative' MP2 depends on MP1	**(2)**

Q5.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	• 23.15 **and** 23.55 **and** 23.20 completed in table **(1)** • ✓ beneath titres **1 and 3 and** mean titre = 23.18 (cm^3) **(1)**	All three titres must be shown to 2 D.P. Allow 23.2 or 23.175 (cm^3)	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	(From)(pale) pink/purple (to) colourless	**Both** colours needed for the mark Do not award mauve or magenta or violet for pink/purple Ignore references to 'clear'	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	• calculation of moles of MnO_4^- in 25.0 cm^3 **(1)** • calculation of moles of NO_2^- in mean titre **(1)** • calculation of moles of NO_2^- in 250 cm^3 **(1)** • calculation of molar mass **(1)** • calculation of ***x*** correctly to the nearest whole number: **(1)**	Example of calculation Moles MnO_4^- = $\frac{0.02(00) \times 25.0}{1000}$ = $5(.00) \times 10^{-4}$ / 0.0005(00) (mol) Moles NO_2^- in mean titre = 2.5 x moles MnO_4^- = 1.25×10^{-3} / 0.00125 (mol) Moles NO_2^- in 250 cm^3 = moles NO_2^- in mean titre x $\frac{250}{\text{mean titre from (a)}}$ = $1.25 \times 10^{-3} \times \frac{250}{23.18}$ = 0.013481449 = 0.0135 (mol) Allow TE on mean titre from (a) Ignore SF except 1 SF • Molar mass = 2 x $\frac{1.15}{0.0135}$ = 170.3703704 (g mol^{-1}) = 170.4 (g mol^{-1}) Allow TE • ***x*** = $\frac{170.4 - 116.3}{18(.0)}$ ***x*** = 3.005555556 ***x*** = 3 (**must** be to nearest whole number) Allow TE from molar mass calculated Allow alternative correct methods for MP4 and MP5 Correct value of ***x*** with no working scores (1)	(5)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)	$2MnO_4^- + 5NO_2^- + 6H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$ • evidence of multiplying 1st equation by 2 **and** 2nd equation by 5 **(1)** • overall equation correct with H^+ and H_2O and $e^{(-)}$ cancelled as appropriate **(1)**	Each of the following equations score **(1)** mark overall: $2MnO_4^- + 5NO_2^- + 16H^+ + 5H_2O \rightarrow 2Mn^{2+} + 5NO_3^- + 8H_2O + 10H^+$ OR $2MnO_4^- + 5NO_2^- + 6H^+ + 5H_2O \rightarrow 2Mn^{2+} + 5NO_3^- + 8H_2O$ OR $2MnO_4^- + 5NO_2^- + 16H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 10H^+ + 3H_2O$ Ignore state symbols, even if incorrect Allow multiples	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	An explanation that makes reference to the following: **Either** • the (calculated) value of ***x*** would be too high **(1)** • The moles of $MgCO_3$ would be too low / the moles of $Mg(NO_2)_2 \cdot xH_2O$ would be too low / the M_r of $Mg(NO_2)_2 \cdot xH_2O$ would be too high **(1)** **Or** • (So) the (calculated) value of ***x*** would be unchanged (so this does not explain the discrepancy) **(1)** • Only a small amount/mass of $MgCO_3$ would dissolve because it is very slightly soluble **(1)**	Allow 'amount' or 'mass' for 'moles' MP2 depends on MP1 MP2 depends on MP1	**(2)**

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Question Number	Acceptable Answers	Additional Guidance	Mark
(f)	An answer that makes reference to the following points: • the $MgCO_3$ would decompose / the residue would contain $NaNO_2$ / the residue would contain (the excess) Na_2CO_3 **(1)** • (so) the (proposed) method is not valid / appropriate / suitable **(1)**	 Ignore references to just 'impurities' M2 dependent on M1	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(g)	An answer that makes reference to the following point: • heat (the sample) to constant mass	 Allow repetition of heating and weighing until there is no change in mass (of the sample) Ignore references to 'brown gas' etc	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(h)	An answer that makes reference to the following points: • use a larger mass (of the hydrated salt) **(1)** • Use a balance that weighs to 3 D.P. (rather than 2 D.P.) **(1)**	 Ignore references to repeat measurements Allow statements such as 'use a balance that weighs to more decimal places' /'greater resolution' / ' a more precise/sensitive balance' Do not allow 'more accurate'	**(2)**

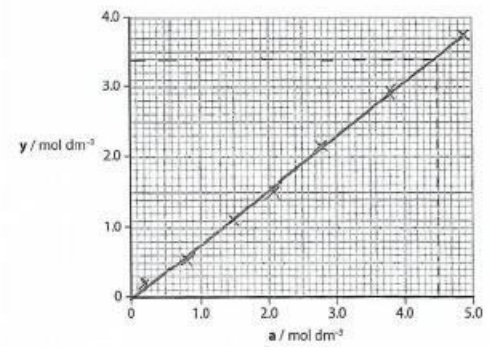
Q6.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	$(K_c =) \frac{[HI(g)]^2}{[H_2(g)][I_2(g)]}$	Ignore missing state symbols or units Do not award round brackets	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	$(K_c =) \frac{4y^2}{(a-y)^2}$ • Numerator term correct (1) • Denominator term correct (1)	Allow square brackets Allow $(2y)^2$ Allow $(a^2 - 2ay+y^2)$ or $(a-y)(a-y)$	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	• both values correct to 2 DP	1.13 2.93	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	• All 7 points plotted correctly (1) • Appropriate straight line of best fit, drawn through the origin (1)	Allow TE for incorrect values from 9(b)(i) Do not allow all points above or below the line of best fit Allow line of best fit to intersect one square either side of the origin	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iii)	• co-ordinates correctly read off the line on graph (1)  • gradient correctly calculated (1)	At least 1 line must be shown on the graph to indicate selection of co-ordinates Example of calculation $\frac{3.40 - 0.00}{4.50 - 0.00}$ = gradient of graph Gradient = 0.76 Ignore SF except 1SF Do not allow units for the gradient Allow a value from 0.71 to 0.81 inclusive	(2)

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Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iv)	• $\frac{\sqrt{K_c}}{2 + \sqrt{K_c}}$ = gradient / $\frac{y}{a}$ (1) • re-arrangement of expression and calculation of K_c (1)	Example of calculation $\frac{\sqrt{K_c}}{2 + \sqrt{K_c}} = 0.76$ K_c = 40.1 /40 (no units) Allow TE on gradient from part (iii) $K_c = [(2 \times grad)/(1-grad)]^2$ Correct answer with no working scores (2)	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	• hydrogen is flammable / explosive	Allow iodine vapour damages eyes /toxic Allow hydrogen iodide is corrosive / acidic / irritant (if qualified) / lachrymator Ignore references to high pressure Ignore references to safety precautions	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)	• Faster rate of reaction / increased rate (1) • K_c unchanged (1)	Ignore references to shifting position of equilibrium	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)(i)	An explanation that makes reference to the following points: • (K_c is) smaller / decreases / gets less (1) • (forward) reaction is exothermic (1)	Allow reverse/backwards reaction is endothermic MP2 dependent on MP1	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)(ii)	• straight line drawn on the graph with a less steep gradient (and goes through the origin)	Do not allow if lines cross	(1)

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of moles of $CaSO_4 \cdot ½H_2O$ (1) • calculation of volume (or mass) of water required (1)	Example of calculation 10.00 g $CaSO_4 \cdot ½H_2O$ = 10.00 ÷ 145.2 mol = 0.06887 mol Allow 0.069 (moles of water required = 0.06887 x 1.5 = 0.1033 mol) volume of water required = 0.1033 x 18 ÷ 1.00 = 1.86 cm^3 Allow 1.86 g Ignore SF except 1 SF Correct answer with no working scores (2) Allow calculation using multiples of these moles (still gets same final answer scores 2) Allow alternative correct calculations: e.g. comparison of moles of $CaSO_4 \cdot ½H_2O$ with moles of water in 10.00 g.	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of ΔT (1) • use of $mc\Delta T$ to find Q (1) • calculation of $\Delta_r H$ (1) • correct final answer, with sign and 2 or 3 SF (1)	Example of calculation ΔT = 2.8 °C m = 10.00 g, c = 4.18 J g^{-1} $°C^{-1}$ Q = $mc\Delta T$ = 117.04 J / 0.11704 kJ Allow M1 and M2 if figure of 117.04 J is seen Ignore units unless converted to kJ 117.04 ÷ 0.06887 = −1699.4 (J mol^{-1}) −1.70 / −1.7 (kJ mol^{-1}) Correct answer with no working scores (4) Allow TE throughout and from 4ci (for moles $CaSO_4 \cdot ½H_2O$)	(4)

Question Number	Answer	Additional Guidance	Mark
(iii)	• selection of thermometer (1) • calculation of percentage uncertainty (1)	Example of calculation $\frac{2 \times 0.5 \times 100}{2.8}$ = 35.7 / 36 / 40 (%) Allow selection of measuring cylinder **and** percentage uncertainty is 5%, scores (1) mark Do not award selection of balance Ignore SF	(2)

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Q8.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	• bottom of meniscus between 23.8 and 23.9 (cm^3) **(1)** • meniscus curved downwards **(1)**	Example of diagram Ignore shading below the meniscus Do not award M2 if there is shading above the meniscus	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a) (ii)	An explanation that makes reference to the following points:	Allow other descriptions of concordant e.g. titres within 0.1 / 0.2 cm^3 Allow (23.1(0) + 23.2(0))/2 = 23.15 (cm^3)	**(2)**
	• 23.15 (cm^3) should be used as it is the mean of the concordant titres / titres 2 and 4 /23.10 and 23.20 (cm^3) **(1)**	Allow only the concordant titres / titres 2 and 4 / 23.20 and 23.20 (cm^3) should be used / are used(in the mean)	
	• 23.43 (cm^3) should not be used as it includes the inaccurate / non-concordant / rough values / titres 1 and 3 / 23.85 and 23.55 (cm^3) **(1)**	Allow the inaccurate / non-concordant / rough values / titres 1 and 3 / 23.85 and 23.55 (cm^3) should not be used / are used (in the mean)	

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(iii)	• calculation of percentage uncertainty	Example of calculation $\frac{2 \times 0.05}{23.20} \times 100$ = (±)0.431 / 0.43 / 0.4 (%) Ignore SF including 1 SF Correct answer with no working scores (1)	**(1)**

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Question Number	Acceptable Answers	Additional Guidance	Mark
(a) (iv)	• calculation of moles of MnO_4^- **(1)** • calculation of moles $C_2O_4^{2-}$ in 25.0 cm^3 **(1)** • calculation of moles $C_2O_4^{2-}$ in 1.00 dm^3 **(1)** • calculation of **y** to nearest whole number **(1)**	<u>Example of calculation</u> moles MnO_4^- = 23.15 x 0.0203/1000 = 0.00046995 / 4.6995 x 10^{-4} (mol) moles $C_2O_4^{2-}$ in 25.0 cm^3 = 4.6995 x 10^{-4} x 5/2 = 0.0011749 / 1.1749 x 10^{-3} (mol) TE on moles MnO_4^- moles $C_2O_4^{2-}$ in 1.00 dm^3 = 1.1749 x 10^{-3} x $\frac{1000}{25.0}$ = 0.046995 / 4.6995 x 10^{-2} (mol) TE on moles $C_2O_4^{2-}$ in 25.0 cm^3 Ratio moles salt : moles $C_2O_4^{2-}$ = 0.0235 : 0.046995 = 1 : 1.9998 **y** = 2 TE on moles $C_2O_4^{2-}$ in 1.00 dm^3 Alternative method for M3 and M4 moles salt in 25.0 cm^3 = 0.0235 x 25.0/1000 = 5.875 x 10^{-4} (1) Ratio moles salt : moles $C_2O_4^{2-}$ = 5.875 x 10^{-4} : 1.1749 x 10^{-3} = 1 : 1.9998 **y** = 2 TE on moles salt and $C_2O_4^{2-}$ in 25.0 cm^3 (1) Ignore SF in working except 1 SF Correct answer with no working scores (1) Allow M4 for correct answer using charges on ions	**(4)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	• calculation of mol of anhydrous salt **(1)** • calculation of mol H_2O **(1)** • calculation of ***z*** to nearest whole number **(1)**	Example of calculation mol anhydrous salt = 2.96/218.1 = 0.013572 / 1.3572 x 10^{-2} (mol) TE on M_r of anhydrous salt from value of **y** in (a)(iv) or an assumed value of ***y*** Allow 0.013578 from M_r 218 mol H_2O (= 0.45/18) = 0.025 / 2.5 x 10^{-2} (mol) Ratio mol salt : mol H_2O = 0.013572 : 0.025 = 1 : 1.842 **z** = 2 TE on moles anhydrous salt and moles H_2O Ignore SF in working except 1 SF Correct answer with some working scores (3) Penalise **y** and **z** not given to nearest whole number once only in (a)(iv) and (b)(i) Allow alternative correct methods	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	An answer which includes the following points: Crystals jumped out of crucible • value of *z* increases **and** because it appears that more mass / mol / water is lost (than expected) **(1)**	Ignore just 'loss in mass / mol'	(5)
	• (this can be prevented by) placing a lid on the crucible **or** heat more gently / carefully **(1)**	Stand alone mark Allow just 'cover the crucible' Ignore use an electrical heater / larger crucible / evaporating basin / conical flask / test tube etc Do not award add anti-bumping granules	
	Not all water of crystallisation lost • less mass / mol /water is lost (than expected) **(1)**	Stand alone mark	
	• (this can be prevented by) heating to constant mass **or** description of heating to constant mass **(1)**	Ignore just 'heat for longer' Do not award the idea of repeating the experiment / using a drying agent	
	• so this accounts for the lower value of *z* / value of *z* decreases **(1)**	Conditional on M3	

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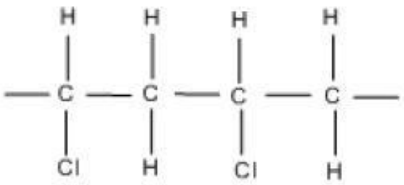
Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • (not using a lid means) some of salt **Y** could be lost from crucible during heating **(1)** • (mass loss greater than expected), so *n* / amount of water (of crystallisation) greater (than expected) **(1)**	Allow solid / product / crystals for 'salt' Allow 'salt spits / jumps out' / 'salt escapes' from crucible Ignore gas escapes Do not award 'salt evaporates' M2 dependent on M1 or salt evaporates	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • (heating for only 1 minute may mean) not all the water (of crystallisation) has been removed **(1)** • (mass loss less than expected), so *n* / amount of water (of crystallisation) less (than expected) **(1)**	Allow evaporated / boiled off for removed Allow (only) partial dehydration Ignore incomplete reaction M2 dependent on M1 or incomplete reaction	**(2)**

Question Number	Answer	Additional Guidance	Mark
(iii)	• • calculation of moles of K_2CO_3 **(1)** • calculation of moles of H_2O **(1)** deduction of n **(1)**	Example of calculation K_2CO_3 / H_2O Moles = 71.9 / (138.2) = 0.52026 / (100 - 71.9) / 18 = 1.56111 Ratio = = 0.52026 / 0.52026 = 1 / = 1.56111 / 0.52026 = 3 n = 3 Accept use of 0.719 / 0.281 in M1 Allow TE from **M1** Allow use of 138 for M_r of K_2CO_3 – gives 0.52101 Ignore SF including 1SF in M1 and M2 M3 must be 1 SF Accept alternative methods e.g. $\frac{138.2}{138.2 + 18n} = 0.719$ (1) 38.8342 = 12.942n (1) so n = 3 (1) **or** M_r of hydrated salt = $\frac{138.2}{0.719}$ = 192.2 (1) mass of water = 192.2 – 138.2 = 54 (1) n = 54/18 = 3 (1) **or** 138.2 = 71.9% so 28.1% **is water** (1) $\frac{138.2}{71.9} \times 28.1 = 54$ (1) n = 54/18 = 3 (1) Correct answer with no working scores (1) Correct answer with some correct working scores (3)	**(3)**

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)		must show **two** repeat units fully displayed allow head to head, head to tail, tail to tail, syndiotactic and isotactic stuctures do not award any other type of formula ignore brackets and n	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • (incineration produces) HCl/chlorinated molecules **(1)** • which are corrosive/toxic /cause acid rain **(1)**	M2 is dependent on M1 allow chlorine ignore carbon dioxide and its consequences allow adverse effect on ozone layer	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: any appropriate precautions to deal with toxic vapours/use fume cupboard etc.	allow good ventilation required allow gas mask/respirator do not award just mask ignore gloves, lab coat	**(1)**

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	$Cl_2 + 2Br^- \rightarrow 2Cl^- + Br_2$	Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • chlorine/bromine toxic/poisonous **(1)** • (Carry out the experiment in a) fume cupboard **(1)** OR • bromine corrosive **(1)** • wear gloves **(1)**	2nd mark dependent on first. Do not award harmful, but allow MP2 if correct for toxic.	**(2)**

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Q12.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	0.816 / 8.16 x 10^{-1} (g)		(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	• calculation of moles of CO_2	Example of calculation: (moles CO_2 = $\frac{225}{24000}$ = 0.009375) Allow 9.375 x 10^{-3} / 9.38 x 10^{-3} / 9.4 x 10^{-3} Ignore SF except 1SF	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)	• moles of MCO_3 **(1)** • method for calculation of molar mass of MCO_3 **(1)** • molar mass final answer to 1, 2 or 3 SF **(1)** • consequential identification of Group 2 metal by name or formula **(1)** NOTE Alternative method can score 3 MAX Calculation of moles of CO_3^{2-} **(1)** (Calculation of mass of CO_3^{2-}) Deduction of mass of M by subtraction **(1)** Calculation of Ar of M to 1, 2 or 3 SF **AND** Identification of group 2 metal **(1)**	Example of calculation: Moles of MCO_3 = moles CO_2 = 0.009375 (mol) Molar mass of MCO_3 = $\frac{0.816}{0.009375}$ (= 87.04 (g mol^{-1})) M2 subsumes mark for M1 = 87.0 / 87 / 90 (g mol^{-1}) NOTE M3 mark subsumes mark for M2 and M1 (87.0 – 60) = 27 **AND** Mg / Magnesium / $MgCO_3$ Allow TE on answers to parts (a) and (b), with Metal consequential on calculated molar mass but M must be a Group 2 element Moles CO_3^{2-} = 0.009375 (Mass of CO_3^{2-} = 0.009375 x 60 = 0.5625 g) Mass of M = 0.2535 g Ar = 0.2535/0.009375 = 27.0 / 27 / 30 (g mol^{-1}) **AND** Mg / Magnesium / $MgCO_3$	(4)

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Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	An explanation that makes reference to the following points: • the bung was not replaced quickly enough **(1)** • (So) CO_2 / gas lost (to the surroundings) **(1)**	 Allow bung not fitting tightly resulting in leaks Ignore references to CO_2 dissolving Ignore references to other types of gas leak Allow 'smaller volume of gas collected' / lower reading of gas volume Mark points M1 and M2 independently	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following point: The acid was (already) in excess (and more acid won't affect this)	Allow The carbonate is the limiting reactant / the acid is not the limiting reactant	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(iii)	An explanation that makes reference to the following points: • rate of reaction is faster **and** powder has greater surface area **(1)** • no effect on (final) volume of gas **and** moles of (metal) carbonate are unchanged **or** because the rate is faster more gas will be lost before the bung is replaced so the (final) volume will be less **(1)**	Mark points M1 and M2 independently Both parts of statement needed Both parts of statement needed Allow mass / amount for moles Allow reactant for metal carbonate	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)(i)	• balanced equation with state symbols	<u>Example of equation:</u> $MCO_3(s) \rightarrow MO(s) + CO_2(g)$ Allow a correct equation for the decomposition of any Group 2 carbonate	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)(ii)	• subtractions to obtain masses **(1)** • calculation of moles of CO_2 **(1)** • calculation of molar mass of MCO_3 **(1)**	Example of calculation: (mass of CO_2 = 20.447 – 20.205) = 0.242 **AND** (mass of MCO_3 = 20.447 – 19.996) = 0.451 moles of CO_2 = $\frac{0.242}{44}$ = 0.0055(0) (mol) / 5.5(0) x 10^{-3} (mol) ALLOW TE from M2 to M3 Mr of MCO_3 = $\frac{0.451}{0.0055(0)}$ = 82 (g mol^{-1}) Correct answer with or without working scores 3 Ignore SF except 1 Ignore attempts to identify the metal	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)	An answer that makes reference to the following point: Student 3 used a smaller mass / less (and the uncertainty of the balance was the same) **or** Student 1 used a larger mass / more (and the uncertainty of the balance was the same)	Allow calculations comparing the two percentage errors: e.g. Student 1:- (0.001/0.816) x 100% = 0.12% **and** Student 3:- 0.001/0.451 x 100% = 0.22%	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(g)	An explanation that makes reference to the following points: • more CO_2 (would appear to be) given off **(1)** • (So) calculated molar mass is smaller **(1)** **OR** • Less MO would appear to have been formed **(1)** • Calculated molar mass would be greater **(1)**	 M2 dependent on M1 M2 dependent on M1	**(2)**

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Q13.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• burette uncertainty **(1)** • pipette uncertainty **(1)**	Example of calculations 0.05 x 2 x 100/ 17.65 = (±)0.567/0.57/0.6(%) 0.06 x 100/25 = (±)0.24/0.2(%) ignore addition of the two uncertainties ignore SF	**(2)**

Question Number	Acceptable Answer	Mark
(ii)	**The only correct answer is B** ***A*** *is not correct because the volume of NaOH needed is divided by 4, uncertainty is x4* ***C*** *is not correct because moles of acid is the same and uncertainty is the same.* ***D*** *is not correct because moles of acid halved and uncertainty doubled.*	**(1)**

Q14.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following point: • sodium amide reacts (vigorously / violently) with water / oxygen	Allow reacts with air Allow will oxidise if not stored in oil / if stored in air Do not award sodium reacts with water / oxygen / air	(1)

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	An answer that makes reference to the following points: • balanced equation with correct species **(1)** • correct states all correct **(1)**	Example of equation: $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$ or $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$ Do not award M2 for incorrect formulae e.g. MgCl (for $MgCl_2$), or H (for H_2) Allow M2 for unbalanced equation if all species correct	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	An answer that makes reference to the following point: • calculation of uncertainty	Example of calculation: $\frac{(\pm)0.5 \times 100}{10.0}$ = (±)5/5.0/5.00(%)	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	An answer that makes reference to the following points: • calculation of moles of Mg **(1)** • calculation of moles of HCl **(1)** • evidence to support Mg in excess **(1)**	Example of calculation: $\frac{0.12}{24.3}$ = 4.9383×10^{-3} / 0.0049383 (mol) Allow *A*, for Mg = 24 $\frac{10 \times 0.20}{1000}$ = 2.0×10^{-3} / 0.002 (mol) 4.9383×10^{-3} mol of Mg requires 9.8765×10^{-3} mol of HCl (and $0.002 < 9.8 \times 10^{-3}$) so Mg in excess or 0.002 mol HCl requires 0.001 mol Mg (and 0.0049 > 0.001) so Mg in excess Ignore SF Do not award **M3** for 0.0049 > 2 x 0.002 OR 0.0049 > 0.004 to show that Mg is in excess Do not award M3 if HCl stated to be in excess	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iii)	calculation of moles of gas	Example of calculation 0.002 ÷ 2 = 0.001 or 1 x 10^{-3} Allow TE from (a) and (b)(ii)	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(iv)	• Rearrangement of ideal gas equation (1) • conversion of °C to K (1) • calculation of volume in m^3 (1) • calculation of volume in cm^3 (1)	Example of calculation: pV = nRT rearrange V = nRT / p Allow M1 if equation rearrangement not explicitly shown but used correctly in M3 (273 + 23) = 296 Allow M2 if (273 + 23) used in equation V = 1.0 / x 10^{-3} x 8.31 x (273 + 23) / 98 000 = 2.51 x 10^{-5} (m^3) = 25 allow 25.1 (cm^3) Allow TE from (b)(iii) and TE at each stage Allow **2 or 3** SF for final answer **ECF values from (b)(iii)** For 0.002 mol H_2, V = 50.2 cm^3 For 0.00494 mol H_2, V = 124 cm^3 For 0.00894 mol H_2, V = 224 cm^3 For 0.004 mol H_2, V = 100 cm^3	

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(i)	An answer that makes reference to the following points: • gas lost before the bung replaced (1) • the magnesium was coated with oxide (so water was formed instead of hydrogen) (1)	Ignore 'generic' gas leakages from apparatus Do not award gas may dissolve (in water or acid) Ignore 'generic' references to impurity Ignore references to incomplete reaction	(2)

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Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to the following points: • arrange equipment so that the Mg ribbon drops into the acid **after** the delivery tube was replaced **(1)** • clean the magnesium ribbon **(1)**	Ignore replace the bung more quickly Allow any workable method	(2)

Q16.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following points: • limewater turns cloudy **(1)** • identifies carbon dioxide **(1)** • anhydrous copper(II) sulfate turns (from white to) blue **(1)** • identifies water **(1)** • the U tube should be placed before the boiling tube **(1)**	Distinguishes water as product of combustion from water originating from the limewater	(5)

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Q17.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• moles of malachite / carbon dioxide **(1)** • convert temperature to kelvin **(1)** • convert pressure to Pa **(1)** • rearrange the expression for V and substitute the candidate's values **(1)** • calculation of V with units and answer to 2 or 3 SF **(1)**	Example of calculation: 0.810/ 221 = 3.66(5158371) x 10^{-3} (mol) temperature = 298 (K) allow for correct temperature in K shown in the calculation Pressure = 101000 (Pa) Allow use of 101 (kPa) if answer given in dm^3 $V = nRT/p$ = 3.66(5158371) x 10^{-3} x 8.31 x 298 ÷ 101000 Correct use of rearranged equation scores M4 =8.98(6460284) x 10^{-5} m^3 =8.99 x 10^{-5} m^3 /9.0 x 10^{-5} m^3/ 0.0899 dm^3 /0.090 dm^3/89.9 cm^3 / 90 cm^3 Use of 300°C / 573 K gives 1.73 x 10^{-4} m^3 Use of 25° gives 7.54 x 10^{-6} m^3 Allow equivalent answers in standard or nonstandard form . Allow TE throughout Correct answer with no working scores 5 marks	(5)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	• 0.556 (%) / 0.56 (%) / 0.6 (%)	Example of calculation: 0.5/89.9 x 100 = 0.556 (%) Allow TE from answer to 6(d)(i) Ignore SF	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	• moles of copper(II) oxide expected (from 0.810 g pure malachite) **(1)** • mass of copper(II) oxide expected (from 0.810 g pure malachite) **(1)** • evaluation of answer **(1)**	Example of calculation: 2 x 3.66(5158371) x 10^{-3}= 7.33(0316742) x 10^{-3} (mol) 7.33(0316742) x 10^{-3} x 79.5 = 0.582(760181) (g) (0.583 (g) scores M1 and M2) % purity = $\frac{\text{actual mass x100}}{\text{expected mass}}$ = $\frac{0.571 \text{ x } 100}{0.582(760181)}$ =	(3)

	OR • moles of copper(II) oxide in 0.571 g **(1)** • moles of copper(II) oxide expected from 0.810 g pure malachite **(1)** • evaluation of answer **(1)** **OR** • calculate mass of CO_2 from decomposition of 0.810 g malachite **and** calculate mass of H_2O from decomposition of 0.810 g malachite **(1)** • calculate total mass of products **(1)** • evaluation of answer **(1)**	97.981(98618) = 98.0(%)/ 98(%) $\frac{0.571}{79.5}$ = 7.18(2389937) x 10^{-3} (mol) 2 x 3.66(5158371) x 10^{-3}= 7.33(0316742) x 10^{-3} (mol) $\frac{7.18(2389937) \times 10^{-3} \times 100}{7.33(0316742) \times 10^{-3}}$ = 97.9(8198618) = 98.0(%) / 98(%) 3.66(5158371) x 10^{-3} x 44 = 0.161(2669683) (g) 3.66(5158371) x 10^{-3} x 18 = 0.0659(7285068) (g) 0.161 + 0.066 + 0.571 = 0.798(239819) (g) $\frac{0.798(239819) \times 100}{0.810}$ = 98.5 (481258) / 99(%) 0.571/ 79.5 = 7.18 x 10^{-3} (mol)	

	OR • calculate moles of CuO in 0.571 g **(1)** • calculate mass of malachite to produce 0.571 g CuO **(1)** • calculate % **(1)**	Moles of malachite = 7.18 x 10^{-3} ÷ 2 = 3.59119 x 10^{-3} (mol) Mass of malachite = 3.59119 x 10^{-3} x 221 = 0.79365 (g) Purity = 0.79365 x 100/0.810 = 97.98198618 (%) =98 / 98.0(%) Allow TE throughout Correct answer with no working scores 3 marks	

Q18.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to two of the following: • rinse the glass rod (into the beaker) **or** rinse beaker (several times) **or** rinse the funnel **(1)** • transfer the washings to the (volumetric) flask **(1)**	Ignore reference to weighing	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to: • removal of the excess solution will remove some of the dissolved sodium hydroxide (so that the exact concentration will be unknown) **or** the concentration won't be known because the total volume will be more than 250cm^3	Allow 'not just removing deionised water' Ignore just 'decrease the concentration'	**(1)**

Q19.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to any **two** of the following: • the tip of the burette must be filled with solution **(1)** • remove the funnel **(1)** • ensure the burette is held vertical **(1)** • eyes are level with the bottom of the meniscus **(1)**	Allow 'jet space' for tip Allow just 'remove air bubbles' Allow 'upright' for vertical Allow 'take readings at eye-level' Allow 'read from the bottom of the meniscus' Ignore reference to clamping and use of stand	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to • the titre will be larger because **either** there is water left in the burette **or** the sodium hydroxide solution will be diluted/lower	Allow the titre will be larger because the burette should have been rinsed with sodium hydroxide	(1)

Q20.

Question Number	Answer	Additional Guidance	Mark
(i)	• completed table	Exemplar table	(1)

Titration number	1	2	3	4
Final burette reading / cm^3	13.00	25.50	37.90	50.00
Initial burette reading / cm^3	0.25	13.00	25.50	37.90
Titre / cm^3	12.75	12.50	12.40	12.10
Concordant titres (✓)		✓	✓	

COMMENT
Allow 12.5/ 12.4 /12.1
Do not award additional ticks

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of percentage measurement uncertainty	Example of calculation (%= ((0.05 x 4) ÷ 12.40 x 100) = 1.6%/1.61% / 2% Ignore SF Do not award 1.65% rounded to 2%	(1)

Q21.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• calculates moles of acid **(1)** • calculates moles of sodium carbonate **(1)** • recognises that (sodium) carbonate is in excess **(1)** • evidence for excess sodium carbonate in terms of moles **(1)** • correct volume of gas calculated with units **(1)**	Example of calculation moles of acid =10.0 x 0.400/1000 =4(.0) x 10^{-3} /0.004 (mol) moles of sodium carbonate =0.242/106.0 = 2.283 x 10^{-3}/0.002283 (mol) recognition of HCl:Na_2CO_3 = 2:1 gets M4 4.0 x10^{-3} mol acid requires 2.0 x 10^{-3} mol sodium carbonate OR 2.283 x 10^{-3} mol of sodium carbonate requires 4.566 x 10^{-3} mol of acid moles CO_2 = 2.0 x 10^{-3} (mol) volume of gas = 2.0 x 10^{-3} x 24 000 = 48 cm^3 /0.048 dm^3 TE on incorrect moles CO_2 correct answer with no working scores 1 mark if the moles of sodium carbonate are not calculated, only M1, M4 and M5 can be awarded. ignore SF except 1 for M5	**(5)**

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Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following reasons: • some gas escaped before the bung/delivery tube was replaced **(1)** • the gas / carbon dioxide is (slightly) soluble in water/ acid / solution **(1)**	ignore references to change in volume when the bung is pushed into the test tube allow 'temperature less than 25°C/298 K/room temperature' as alternative to either answer do not award an incomplete reaction do not award leaky apparatus/sticking syringe	**(2)**

Q22.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	An answer that makes reference to the following points: • 3300 — 2500 (cm^{-1}) **and** O-H (bond) **(1)** • 1725 — 1700 (cm^{-1}) **and** C=O (bond) **(1)**	Allow any value(s) within the range 3300 — 2500 (cm^{-1}) Allow -OH Allow any value(s) within the range 1725 — 1700 (cm^{-1}) Allow 1320 – 1210 (cm^{-1}) **and** C-O	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following points: • structures 1 and 2 will have an absorption at Either C=C at 1669 — 1645 (cm^{-1}) **or** C—H in an alkene at 3095 — 3010 (cm^{-1}) **(1)** • only structure 2 will have an absorption due to the presence of an alcohol / O—H at 3750 —3200 (cm^{-1}) **(1)** • structure 3 will have none of these absorptions / will not show C=C absorption / C-H absorption for an alkene **(1)**	Reject C=C at 3010 (cm^{-1})	**(3)**

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Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	• calculation of moles of NaOH **(1)** • calculation of mass of NaOH **(1)**	Example of calculation: (moles NaOH = 0.140 x 250) 1000 = 0.035(0) (mol) = 40(.0) x 0.035(0) = 1.4(0) (g) Correct answer with or without working scores 2 marks Allow TE for M2 on moles of NaOH Alternative route, allow M1 for conversion of concentration to 5.6 g dm^{-3} Ignore SF	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to the following points: • (because the) sodium hydroxide has been diluted **(1)** • (the titre will be) smaller **(1)**	Allow Fewer moles of sodium hydroxide present / some sodium hydroxide will have been removed M2 dependent on M1	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) **(1)** M2 because the (number of) moles of sodium hydroxide is unaffected **(1)**	M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow amount / mass of sodium hydroxide is unaffected	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(iii)	• calculation of percentage uncertainty in burette volume **(1)** • calculation of percentage uncertainty in volumetric flask volume **and** in pipette volume **(1)** • identification of volume with the lowest percentage uncertainty **(1)**	Example of calculation: 2 x (±)0.05 / 10.20 x 100% = (±)0.980392156% (±)0.30 / 250.0 x 100% = (±)0.12% **and** (±)0.040 / 10.0 x 100% = (±)0.4% Volumetric flask has the lowest uncertainty Allow TE for identification in M3 Allow ANY number of SF in answer, from 1 SF up to calculator value	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	• left-hand side of equation correct **(1)** • right-hand side of equation correct **(1)**	Example of equation $HOOCCH{=}CHCOOH + 2NaOH \rightarrow NaOOCCH{=}CHCOONa + 2H_2O$ ALLOW use of molecular formulae or ionic equation: $C_4H_4O_4 + 2NaOH \rightarrow Na_2C_4H_2O_4 + 2H_2O$ $HOOCCH{=}CHCOOH + 2OH^- (+ 2Na^+) \rightarrow {}^-OOCCH{=}CHCOO^- + 2H_2O (+ 2Na^+)$ ALLOW Multiples Correct charges Do not award if O–Na covalent bond drawn IGNORE State symbols, even if incorrect	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points: • (New mean titre) = 20.4(0) (cm^3) / double (the original value) **(1)** • For structure 2, mole ratio / reacting ratio is 1:1 (with NaOH) **(1)**	Mark M1 and M2 independently Allow structure 2 has 1 COOH / 1 acid group	**(2)**

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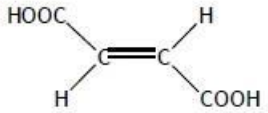
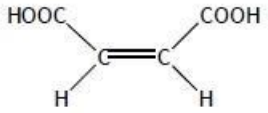
Question Number	Acceptable Answers	Additional Guidance	Mark
(e)		3 correct ticks with no crosses scores 1 Ignore descriptions of result in terms of colour (changes) / reactions occurring	(2)

Structure	Test with Br_2 water	Test with acidified $K_2Cr_2O_7$
HOOCCH=CHCOOH	✓	x
$HOCH_2CH=CHCH_2COOH$	✓	✓
$CH_3CH_2CH_2CH_2CH_2COOH$	x	x

Left hand column correct **(1)**
Right hand column correct **(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(i)	• *E*-isomer:  **(1)** • *Z*-isomer:  **(1)**	ALLOW skeletal or displayed structures ALLOW $-CO_2H$ IGNORE Connectivity to the –COOH group IGNORE bond angles Award one mark if correct structures are drawn, but *E*- and *Z*-isomers labelled the wrong way round Award 1 mark if incorrect molecule used but *E* - and *Z*- isomers are correct	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(ii)	An answer that makes reference to the following points: • restricted / limited rotation (about the C=C double bond)**(1)** • each carbon atom in the double bond is attached to (two) different atoms / different groups (of atoms) / to a H (atom) and a COOH group **(1)**	Allow "no rotation" Do not award the carbons are attached to 2 "different molecules" Mark points M1 and M2 independently	(2)

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Q23.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	• potassium dichromate((VI))/$K_2Cr_2O_7$ and sulfuric acid/H_2SO_4 **or** sodium dichromate((VI))/$Na_2Cr_2O_7$ and (dilute) sulfuric acid/H_2SO_4 **(1)** • heat/reflux **(1)**	Allow $Cr_2O_7^{2-}$ and H^+ / acidified (potassium / sodium) dichromate((VI)) If name and formula given, both must be correct Ignore concentration of acid Do not allow hydrochloric acid / HCl / nitric acid / HNO_3 Conditional on correct reagents or near miss, provided dichromate or (per)manganate((VII)) is mentioned Allow a specified temperature in the range 60 – 150°C Ignore distillation / warm Allow answers written on either dotted line	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	A description that makes reference to the following points: • **Flask** - use of a volumetric / graduated flask **(1)** • **Weighing** - weigh the ethanedioic acid (in a weighed container and record the exact mass) **(1)** • **Dissolve, transfer and washings** – allow these in any order depending on the method used **(1)** • **Mark and mix** - make up to the mark / 250 cm^3 and then mix **(1)**	Ignore heat Do not allow just 'flask' / conical flask Ignore just 'put 1 /1.0 /1.09 g solid in beaker' Distilled / deionised water must be mentioned once in M3 or M4 Allow pure water Allow any indication of mixing eg swirl / invert the flask	**(4)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	• (From) colourless (to) pink	Allow (to) red Do not allow purple / pink/purple Do not allow clear	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iii)		Correct answer of 2.2582/2.258/2.26/2.3 without working scores 5 Final answer of 2, with working, resulting from a number between 2.2 and 2.3, scores 5 If no other mark is scored, an answer of just 2 scores 1	(5)
	• calculation of moles of NaOH (1)	<u>Example of calculation</u> moles NaOH = 16.2 x 0.103/1000 = 1.6686×10^{-3}	
	• calculation of moles of $H_2C_2O_4$ in 25 cm^3 (1)	moles $H_2C_2O_4$ in 25 cm^3 = $1.6686 \times 10^{-3}/2 = 8.343 \times 10^{-4}$ TE on mole NaOH	
	• calculation of moles of $H_2C_2O_4$ in 250 cm^3 (1)	moles $H_2C_2O_4$ in 250 cm^3 = $8.343 \times 10^{-4} \times 10 = 8.343 \times 10^{-3}$ TE on moles $H_2C_2O_4$ in 25 cm^3	
	• calculation of M_r of crystals (1)	M_r of crystals = $1.09/8.343 \times 10^{-3}$ = 130.648 /130.65 / 130.6 TE on moles $H_2C_2O_4$ in 250 cm^3 For first 4 marking points ignore SF except 1 SF	
	• calculation of value of n (1)	130.65 = (2 + (2x12) + (4x16)) + 18n n = 2.2582/ 2.258/2.26/2.3/2 TE on M_r of crystals, provided n is positive	

	Alternative method for M4 and M5 • calculation of moles of H_2O (1) • calculation of value of n (1)	mass $H_2C_2O_4$ = $8.343 \times 10^{-3} \times 90$ = 0.75087 (g) mass H_2O = 1.09 – 0.75087 = 0.3391 (g) moles H_2O = 0.3391/18 = 0.01884 mole ratio $H_2C_2O_4$: H_2O = 1 : $0.01884/8.343 \times 10^{-3}$ = 1 : 2.2582/ 2.258/2.26/2.3/2	

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Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iv)	An explanation that makes reference to the following points: • (damp crystals will have more water so) lower mass / moles / concentration of $H_2C_2O_4$ **(1)** • so titre will be lower and the value of n will be higher **(1)**		(2)

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