PEARSON EDEXCEL A-LEVEL CHEMISTRY · 9CH0

CHEMISTRY



MARK SCHEME

TOPIC 5: FORMULAE, EQUATIONS AND AMOUNTS OF SUBSTANCE

SCORE	PERCENTAGE
/537	%

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Q83.

Boric acid, H_3BO_3, is a weak acid with antiseptic properties.

Boric acid can be prepared by reacting borax, $Na_2B_4O_7.10H_2O$, with hydrochloric acid.

Write the equation for this reaction. State symbols are not required.

(1)

(Total for question = 1 mark)

Mark Scheme

Q1.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• 3-methylbutan-2-ol / secondary alcohols cannot be oxidised to a carboxylic acid OR • 3-methylbutanone / the product / ketones cannot be (further) oxidised	Allow only primary alcohols can be oxidised to carboxylic acids	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• H_2SO_4	Ignore 'sulfuric acid'	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(iii)	• all formulae correct **(1)** • all state symbols correct **(1)**	Example of equation: $Na_2CO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$ OR $Na_2CO_3(s) + 2H^+(aq) \rightarrow 2Na^+(aq) + H_2O(l) + CO_2(g)$ OR $Na_2CO_3(s) + 2H_2SO_4(aq) \rightarrow 2NaHSO_4(aq) + H_2O(l) + CO_2(g)$ Use of $NaCO_3$ or H_2CO_3 scores zero Allow any acid. M2 consequential on M1 being awarded, or a 'near-miss'	(2)

Q2.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	Any one from: Catalyst / speeds up reaction / increases rate / increases rate of attainment of equilibrium / lowers activation energy	Ignore any mention of protonation or mechanism for catalysis Do not award additional incorrect types of reaction	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	• calculation of moles of H^+ in 25.0 cm^3 **(1)** • calculation of moles of H^+ in 250 cm^3 flask **(1)**	Ignore SF throughout 8(b)(i) to 8(c)(ii) except 1 SF, which should be penalised once only Example of calculation: (moles NaOH = 0.200 x $\frac{23.60}{1000}$) = 0.00472 (mol) (= mol H^+ in 25.0 cm^3) (= 10 x 0.00472) = 0.0472 (mol) (in 250 cm^3) Allow TE for M2 on moles of NaOH Correct answer with or without working scores 2 marks	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	• subtracts moles of H^+ in HCl from answer to (b)(i)	Example of calculation: 0.0472 – 0.00400 = 0.0432 (mol) Allow TE on answer to part (b)(i)	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(i)	• calculation of moles of CH_3COOH that have reacted	Example of calculation: (0.105 — 0.0432) = 0.0618 Allow TE on part (b)(ii) unless negative value	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	• calculation of equilibrium moles of $CH_3CH_2CH_2OH$ **(1)** • calculation of equilibrium moles of $CH_3COOCH_2CH_2CH_3$ **(1)** • calculation of equilibrium moles of H_2O **(1)**	Example of calculation: 0.0800 — 0.0618 = 0.0182 0.0618 0.111 + 0.0618 = 0.1728 Allow TE on answer to part (c)(i) unless negative value	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	$(K_c =)$ $\frac{[CH_3COOCH_2CH_2CH_3][H_2O]}{[CH_3COOH][CH_3CH_2CH_2OH]}$	IGNORE state symbols even if incorrect Do not award round brackets	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An explanation that makes reference to the following points: • Same number of moles/molecules on both sides of the equation **(1)** • (so) volume / V cancels in K_c expression **(1)**	2 marks could be scored by a correct mathematical expression showing V or dm^3 cancel Allow same number of terms on top and bottom of K_c expression Allow units cancel out Allow "**all** divided by the same volume"	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(iii)	• calculates value of K_c **(1)** • final value of K_c quoted to 2 or 3 SF **(1)**	Example of calculation $K_c = \frac{(0.0618) \times (0.1728)}{(0.0432) \times (0.0182)} = 13.58241758$ = 14 / 13.6 (no units) Correct answer with no working gains full marks Ignore units No TE on wrong K_c expression	2

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	An explanation that makes reference to the following points: • the equilibrium shifts to the left **or** the mixture absorbs carbon dioxide from the atmosphere **(1)** • so the mixture is (becoming more) acidic / the acid reforms **(1)**	Mark independently Allow no longer alkaline Do not award just "pH decreases"	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)	An explanation that makes reference to the following points: • carry out / repeat experiment **and** leave for longer than a week **(1)** • the titre value / K_c value will remain unchanged (if equilibrium has been established) **(1)**	Ignore pH probes / checking pH Allow repeat experiment **and** check titres within first week Allow moles / concentration are unchanged Ignore just "results unchanged"	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(g)	An answer that makes reference to the following points: • K_c value will be greater than that calculated in (d)(iii) **(1)** • because the (forward) reaction is endothermic **or** backward / reverse reaction is exothermic **(1)**	M2 depends on M1 Ignore References to the equilibrium position shifting to the right (with increasing temperature)	**(2)**

Q3.

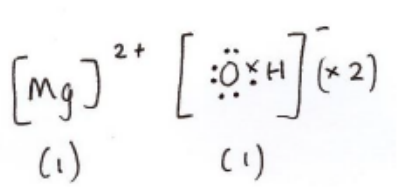
Question Number	Answer	Mark
(i)	**The only correct answer is C (homolytic bond fission to form free radicals)** *A is incorrect because such bond fission would produce ions* *B is incorrect because the first step of the reaction produces free radicals by homolytic fission* *D is incorrect because the first step of the reaction produces free radicals*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	122.9 ÆÆ(122.9 + 80.9) x 100 **or** 122.9 ÆÆ(44.0 + (2 x 79.9)) x 100 **or** (122.9ææ203.8) x 100 (1) = 60.304% (1)	Allow 123 ÆÆ (123+81) = 60.29% Award M1 only if final answer given as decimal 0.603 rather than % Allow TE for M2 for only one incorrect A_r value Ignore SF Correct answer with or without working scores (2)	**(2)**

Question Number	Answer	Mark
(iii)	**The only correct answer is D** (the reaction produces a mixture of organic products) *A is incorrect because bromine is very reactive* *B is incorrect because gaseous reactants do not necessarily give a poor yield* *C is incorrect because the kinetics of the reaction do not affect the yield*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iv)	Amount of 1-bromopropane (1) So moles of propane required (1) So volume of propane required to 2 or 3 SF (1) **Alternative route** Target mass of 1-bromopropane required to produce 14.7 g (with a 31.0% yield) (1) Moles of propane required to produce the required mass of 1-bromopropane (1) So volume of propane required to 2 or 3 SF (1)	14.7/122.9 = 0.11961 (mol) (0.11961/31) x 100 = 0.38584 (mol) = 0.38584 x 24.0 = 9.2601 (dm^3) = 9.3 / 9.26 (dm^3) Allow 14.7/123 = 0.11951 (mol) (0.11951/31) x 100 = 0.38552 (mol) = 0.38552 x 24.0 = 9.2526 (dm^3) = 9.3 / 9.25 (dm^3) 14.7 x $\frac{100}{31.0}$ = 47.4 g $\frac{47.4}{122.9}$ = 0.3857 (mol) 0.3857 x 24.0 = 9.3 / 9.26 (dm^3) Award (2) for a final answer of 0.890 / 0.89 (dm^3) (incorrect use of 31.0%) Answer assuming 100% yield scores (2) for final answer of 2.87 / 2.9 (dm^3) Penalise incorrect units in M3 Do not award M3 if Ideal Gas Eqtn used for propane volume Penalise incorrect rounding once only **Correct answer to 2 or 3 SF with or without working scores (3)**	**(3)**

Q4.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	 (1) (1)	For Mg allow 0 or 8 electrons in outermost shell Ignore inner shell electrons	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	• amount of NaOH (1) • [NaOH] (1) • $[NaF]_{eq}$ (1) • K_c expression (1) • Value of K_c (1)	Example of calculation 11.7/1000 x 0.100 = 0.00117 / 1.17 x 10^{-3} 0.00117/(25/1000) = 0.0468 mol dm^{-3} 0.250 – 0.0468 = 0.2032 mol dm^{-3} $K_c = [NaOH]^2 / [NaF]^2$ 0.0530 (no units)	**5**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (ii)	An answer that makes reference to the following point: • No, as temperature is likely to be different on different days and this affects value of K_c	Allow 'yes, but only if the temperature is the same'	**1**

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	• named indicator **(1)** • matching colour **change** **(1)** • pH range (of indicator) / quoted range lies (completely) in the vertical region (on the titration curve) **or** indicator will change colour in the vertical / straight / steep region of the graph **or** pH range of indicator and pH range of vertical region of the graph stated, as long as they overlap **(1)**	<u>Examples of indicators and colour changes</u> phenol red – red to orange / yellow phenolphthalein ((in ethanol)) – red / pink to colourless (do not allow purple or clear) bromothymol blue – blue to yellow M2 is conditional on a correct indicator in M1 Do not allow unsuitable indicators e.g. litmus Stand alone mark Allow pK_{in} (± 1) is in the vertical jump **or** pK_{in} is nearest to the pH at the end / equivalence point **or** indicator will change colour at the end / equivalence point **or** (because it is a) titration of a weak acid with a strong base	**(3)**

Question Number	Answer	Mark
(ii)	**The only correct answer is C** ***A*** *is not correct because used the volumes the wrong way round* ***B*** *is not correct because not used the volume of glycolic acid from the graph* ***D*** *is not correct because used a 1:2 mole ratio*	**(1)**

Question Number	Answer	Mark
(iii)	**The only correct answer is C** ***A*** *is not correct because this is the pH of glycolic acid* ***B*** *is not correct because this is the pH at the end of the vertical jump in the curve* ***D*** *is not correct because this is the pH at the start of the vertical jump*	**(1)**

Q6.

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)**

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)

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)**

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)**

Q7.

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)		Example of calculation	**(5)**
	• calculation of moles of MnO_4^- in 25.0 cm^3 **(1)**	Moles MnO_4^- = $\frac{0.02(00) \times 25.0}{1000}$ = 5(.00) x 10^{-4} / 0.0005(00) (mol)	
	• calculation of moles of NO_2^- in mean titre **(1)**	Moles NO_2^- in mean titre = 2.5 x moles MnO_4^- = 1.25 x 10^{-3} / 0.00125 (mol)	
	• calculation of moles of NO_2^- in 250 cm^3 **(1)**	Moles NO_2^- in 250 cm^3 = moles NO_2^- in mean titre x $\frac{250}{\text{mean titre from (a)}}$ = 1.25 x 10^{-3} x $\frac{250}{23.18}$ = 0.013481449 = 0.0135 (mol) Allow TE on mean titre from (a) Ignore SF except 1 SF	
	• calculation of molar mass **(1)**	• Molar mass = 2 x $\frac{1.15}{0.0135}$ = 170.3703704 (g mol^{-1}) = 170.4 (g mol^{-1}) Allow TE	
	• calculation of ***x*** correctly to the nearest whole number: **(1)**	• ***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)	

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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)**

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)**

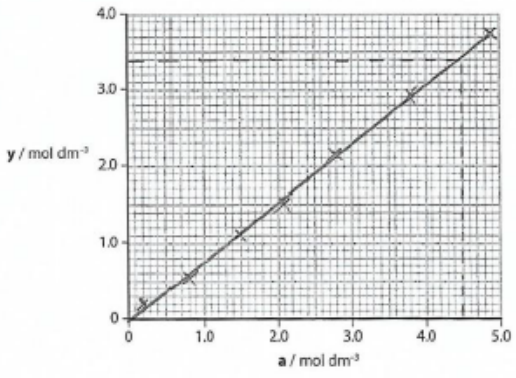
Q8.

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

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	$(K_c =) \dfrac{4y^2}{(a - y)^2}$ • 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 3.40 – 0.00 = gradient of 4.50 – 0.00 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)**

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) $K_c = [(2 \times \text{grad})/(1-\text{grad})]^2$ 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)

Q9.

Question Number	Acceptable Answer	Additional guidance	Mark
	• Balanced equation **(1)** • Appropriate colours **(1)**	Example of equation: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ Allow multiples Orange colourless green colourless Allow 'No colour' for colourless Do not award 'blue' for 'green' Do not award 'clear' for colourless Do not award if any spaces left blank Ignore any colour given for electrons Ignore any shades of colour	**(2)**

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	• mass of carbon in both substances **(1)** • molar masses of both substances **(1)** • calculation of percentages by mass of carbon **(1)**	Example of calculation (12 x 7 =) 84 Phenylmethanol 108 and Benzoic acid 122 Phenylmethanol (84 ÷ 108) x100 = 78%/ 77.8%/ 77.78% / 77.7 % Benzoic acid (84 ÷ 122) x 100 = 68.85%/ 68.9%/69% Ignore sf except 1 Allow TE on incorrect M_r values Allow (2) for 11.1% and 9.8% calculated using 12 not 84 Allow 'rescue' (1) for one substance completely correct	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to: • black smoke	Allow Black fumes/soot/(yellow) smoky flame / grey smoke Ignore carbon particulates Do not award carbon monoxide/yellow flame	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to • Alkenes	Allow Cycloalkenes/cycloalkanes/alkynes/ carbon-carbon double bonds Ignore Ethene/named alkenes/named alkynes Do not award benzene/arenes	(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	An explanation that makes reference to • (window) above the safety line means the exhaust system is not strong enough to draw in the fumes **(1)** • so the toxic fumes will escape (into the laboratory) **(1)**	Allow reverse argument Allow reference to exhaust/fan not able to prevent gas escaping Allow poisonous/harmful/irritant/ carbon monoxide/soot for 'toxic fumes' Ignore reference to protection from splashing etc	(2)

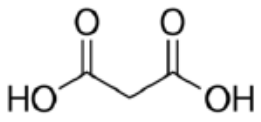
Q11.

Question number	Answer	Additional guidance	Marks
	• determines number of mol of CO_2 produced (1) • calculates number of mol NaO_2 in 880 g (1) • calculates the number of mol of CO_2 reacted with NaO_2 and hence determines the number of mol of CO_2 in excess (1) • calculation of mass of Na_2O = 248 g (1)	<u>Example of calculation</u> 2 mol glucose produces 12 mol CO_2 880 g NaO_2 = 16 mol 16 mol NaO_2 remove 8 mol CO_2 (therefore 4 mol CO_2 is excess) mass of Na_2O required is (4 x 62) = 248 g 3rd mark is csq on answers given in 1st and 2nd marks 4th mark is csq on answer given in 3rd mark Correct answer with units and no working scores 4 marks.	4

Q12.

Question Number	Answer	Additional Guidance	Mark
	• Expression of numerator and denominator for atom economy (1) • evaluation (1)	Example of calculation **28 ÷ [28 + 106]** (x 100) / **[28 ÷ 134]** (x 100) 20.896 = 20.9% Ignore SF except 1 SF Allow TE for M2 for 1 M_r error in M1 Allow 1 mark for (106 ÷ 134) x 100 = 79.1 %	(2)

Q13.

Question Number	Answer	Additional Guidance	Mark
	• calculation of amount of sodium hydroxide (1) • calculation of amount of **Y** in 25.0 cm^3 (1) • calculation of amount of **Y** in 250 cm^3 (1) • calculation of molar mass of **Y** (1) • deduction of structure of **Y** (1)	Example of calculation 26.10/1000 x 0.320 = 8.352×10^{-3} (mol) 8.352×10^{-3} / 2 = 4.176×10^{-3} (mol) 4.176×10^{-3} x (250/25) = 4.176×10^{-2} (mol) 4.34 / 4.176×10^{-2} = 103.9 / 104 (g mol^{-1})  Allow structural / displayed / skeletal or any combination Allow TE throughout M1-M4 Penalise 1 SF in M1	(5)

Q14.

Question Number	Answer	Additional Guidance	Mark
	• calculation of moles of pent-1-ene (1) • conversion of volume and temperature (1) • rearrangement of ideal gas equation and calculation of *p* (1) • final answer to 2 or 3 SF **and** units (1)	Example of calculation 1.33 / 70 = 0.019 (mol) 500 x 10^{-6} m^3 and 333 K Allow conversion of volume to 0.5 dm^3 if units for M3 and / or M4 shown as kPa $P = (nRT) / V$ = (0.019 x 8.31 x 333) / 500 x 10^{-6} = 105154.74 = 105000 Pa / 1.05 x 10^5 Pa / 1.1 x 10^5 Pa Allow N m^{-2} for Pa Allow 105 kPa Allow TE at each stage Penalise rounding to 1SF in M1 but then allow TE Correct answer with units and no working scores (4)	(4)

Q15.

Question Number	Answer	Mark
	The only correct answer is C (31.2 dm^3) **A** *is not correct because the answer assumes a 1:1 ratio of butane to oxygen* **B** *is not correct because the answer assumes a 1:2 ratio of butane to oxygen* **D** *is not correct because the answer assumes a 1:13 ratio of butane to oxygen*	(1)

Q16.

Question Number	Answer	Additional Guidance	Mark
	• conversion of moles to mass of paracetamol **(1)** • conversion of answer into percentage to 2/3 SF **(1)**	Example of calculation: (mass of paracetamol = $3.10 \times 10^{-3} \times 151 = 0.4681$ (g) % = (0.4681÷ 0.500) x 100 = 93.62%) =94 (%)/93.6 (%) Allow TE for second mark from incorrect molar mass as long as value derived from dividing by 0.500/500mg and percentage is less than 100% Correct answer without working scores 2	**(2)**

Q17.

Question Number	Answer	Additional Guidance	Mark
	• (M1) calculation of concentration of diluted acid **(1)** • (M2) calculation of pH **(1)**	Example of calculation $c=(15 \times 15.9 / 100) = 2.385$ (mol dm^{-3}) pH=−log(2.385) = −0.377/−0.38 / −0.4 TE on M1 provided answer is <7 Final answer without working scores (2) Ignore SF	(2)

Q18.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• calculates mol of propan-1-ol (1) • calculates mol of 2-bromopropane produced (1) • calculates mass of 2-bromopropane (1)	Example of calculation mol propan-1-ol = 3.0/60 = 0.05 mol 2-bromopropane produced = 0.05 x 0.65 x 0.58 = 0.01885 mass of 2-bromopropane = 0.01885 x 122.9 = 2.317 (g) = 2.3 (g) ignore sf except 1 sf	**3**

Q19.

Question number	Answer	Additional guidance	Marks
	• calculation of number of moles Na_2O_2 (= mols H_2O_2) (1) • calculation of number of moles Ce^{4+} (1) • determination of the ratio H_2O_2 : Ce^{4+} (1) • formula of cerium ion is Ce^{3+} (1)	Example of answer $n(Na_2O_2) = (0.403 \div 78.0) = 5.17 \times 10^{-3}$ $n(Ce^{4+}) = (24.85 \div 1000 \times 0.420) = 1.04 \times 10^{-2}$ $n(Ce^{4+}) : n(H_2O_2) = 1.04 \times 10^{-2} : 5.17 \times 10^{-3} = 2 : 1$ 1st and 2nd mark; accept answers to any significant figures, except 1s.f 3rd mark csq on answers given in 1st and 2nd marks 4th mark csq on answer given in 3rd mark	**4**

Q20.

Question Number	Answer	Additional guidance	Mark
	• initial moles of NaOH in 250 cm^3 (1) • excess moles of NaOH in 25.0 cm^3 (1) • expression for moles of total NaOH reacted (1) • evaluation of moles of cinnamic acid (1) • evaluation of M_r of cinnamic acid to 1 d.p. (1)	Example calculation Initial moles of NaOH = (250 ÷ 1000) x 0.500 = 0.125 Moles of excess NaOH in 25.0 cm^3 = (28.25 ÷ 1000) x 0.400 = 0.0113 Moles of NaOH reacted = 0.125 – (10 x 0.0113) Moles of cinnamic acid = moles of NaOH reacted = 0.012 M_r of cinnamic acid = 1.78 ÷ 0.012 = 148.3 Allow ecf from 2nd mark Correct answer **to 1d.p.** with no working scores 5 marks	**5**

Q21.

Question Number	Correct Answer	Reject	Mark
	B		1

Q22.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• +5		**1**

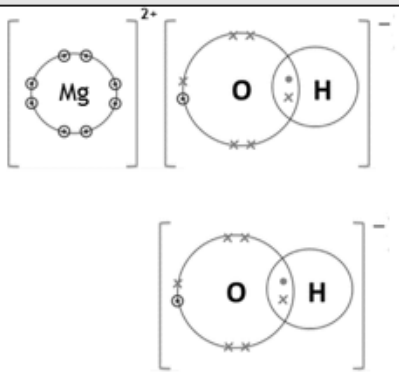
Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (i)	• choice of suitable reducing agent	From Data Booklet of the standard electrode potentials, the right hand substance in numbers 16-24	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (ii)	An answer that makes reference to the following point: • may be kinetically hindered **or** activation energy may be too high	Allow reaction may be too slow	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (iii)	An explanation that makes reference to the following points: • (yellow to) green then blue (1) • when the blue colour initially forms, it mixes with the yellow unreacted VO_2^+ (to turn green) (1)	Ignore colours caused by contamination with reducing agent chosen	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (iv)	An explanation that makes reference to the following point: • justification of choice (1) • correct equation for reaction (1)	$E^\ominus$ value is between +0.34 V and −0.26 V Allow by comparison of electrode potentials / calculation of E_{cell} / use of anti-clockwise rule $S_2O_3^{2-} + VO^{2+} + 2H^+ \rightarrow V^{3+} + H_2O + \frac{1}{2}S_4O_6^{2-}$ or multiples	**2**

Q23.

Question Number	Answer	Additional Guidance	Mark
(i)	• magnesium ion (1) • hydroxide ion (1)	 Allow all dots or all crosses Allow M1 for magnesium ion outer shell shown with no electrons Allow M2 even if only 1 hydroxide ion is shown Ignore inner shells Ignore absence of square brackets and circles Ignore any indication of 2 hydroxide ions e.g. 1 hydroxide ion with '2' preceding it Penalise missing charges once only	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)		Example of calculation	(5)
	• calculation of moles of $Mg(OH)_2$ **(1)**	0.174 ÷ 58.3 = 2.98456 x 10^{-3} (mol)	
	• calculation of mass of $Mg(NO_3)_2$ **(1)**	2.98456 x 10^{-3} x 148.3 = 0.44261 (g)	
	• calculation of mass of H_2O **(1)**	0.765 - 0.44261 = 0.32239 (g)	
	• calculation of moles of H_2O **(1)**	0.32239÷18 = 0.017911 (mol)	
	• deduction of $Mg(NO_3)_2$: H_2O ratio (and hence formula) **(1)**	0.017911÷ 2.98456 x 10^{-3} = 6.0011 1:6, (so $Mg(NO_3)_2.6H_2O$)	
	OR		
	• Calculation of moles of $Mg(OH)_2$ **(1)**	0.174 ÷ 58.3 = 2.98456 x 10^{-3} (mol)	
	• deduction of moles of $Mg(NO_3)_2.xH_2O$ **(1)**	1:1 so = 2.98456 x 10^{-3} (mol)	
	• expression for / calculation of molar mass of $Mg(NO_3)_2.xH_2O$ **(1)**	148.3 + 18x / 0.765 ÷ 2.98456 x 10^{-3} = 256.3	
	• expression for moles of $Mg(NO_3)_2.xH_2O$ in terms of mass and molar mass / calculation mass of water in 1 mole **(1)**	0.765÷(148.3 + 18x) = 2.98456 x 10^{-3} (mol) / 256.3 - 148.3 = 108 0.32239 = 0.0537x, so x = 0.32239÷0.0537 = 6.0035 / 108÷18 so x = 6 ; (so $Mg(NO_3)_2.6H_2O$)	
	• calculation of x (and hence formula) **(1)**	Correct answer with no working scores M5 only. Ignore SF from M1 to M4, allow TE throughout	

Q24.

Question Number	Answer	Additional Guidance	Mark
(i)	• balanced equation	Example of equation $3Cl_2 + 6OH^- \rightarrow 5Cl^- + ClO_3^- + 3H_2O$ Allow multiples Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
(ii) Clip with (i)	An explanation that makes reference to the following points: • oxidation number for chlorine changes from 0 to -1 so it is **reduced** **(1)** • oxidation number for chlorine changes from 0 to +5 so it is **oxidised** **(1)**	Ignore general definitions of disproportionation Accept oxidation numbers and their changes shown with equation Allow 1 out of 2 marks for three correct oxidation numbers of the chlorine	**(2)**

Q25.

Question Number	Answer	Additional Guidance	Mark
	• calculation of mass of C from CO_2 (1) • calculation of mass of H from H_2O (1) • subtraction to find mass of O, and evaluation of number of moles of C, H and O (1) • confirm whole number ratio (1)	Example of calculation Mass of C = 4.26 x 12/44 = 1.1618 g Mass of H = 1.1 x 2/18 = 0.12222 g So mass O = 1.56 – (1.1618 + 0.1222) = 0.27598 g Moles C = 1.1618/12 = 0.096817 Moles H = 0.12222/1 = 0.12222 Moles O = 0.27598/16 = 0.017249 Ratio = 5.6 : 7.1 : 1 = 11 : 14 : 2 Allow alternative correct methods	**4**

Q26.

Question Number	Answer	Mark
(i)	**The only correct answer is A** (50 cm^3) ***B*** *is incorrect because this is the increase in volume from 200 cm^3 of ethane* ***C*** *is incorrect because this is the volume of CO_2 formed* ***D*** *is incorrect because this is the total volume of CO_2 and H_2O formed*	**(1)**

Question number	Answer	Additional Guidance	Mark
(ii)	• calculation of x **(1)** • calculation of y **(1)** • structure of cyclopentene **(1)**	Example of calculation (volume of CO_2 = 125 (cm^3) so x = 125/25) = 5 (25 + 25(5 + (y/4)) − 75 = 125) y = 8  Allow the skeletal formula of any cyclic C_5H_8 compound with C=C e.g. a methylcyclobutene TE on x and y for a cyclic hydrocarbon	**(3)**

Q27.

Question Number	Answer	Additional Guidance	Mark
	• calculation of moles of $KBrO_3$ **(1)** • calculation of moles of O_2 **(1)** • calculation of volume of O_2 **(1)**	Example of calculation moles of $KBrO_3$ = $\frac{5.20}{(39.1 + 79.9 + (3 \times 16.0))} = \frac{5.20}{167(.0)}$ = 0.031138 / 3.1138×10^{-2} (mol) moles of O_2 = $\frac{0.031138 \times 3}{2}$ = 0.046707 / 4.6707×10^{-2} (mol) TE on moles of $KBrO_3$ volume of O_2 = 0.046707 x 24 = 1.12096 (dm^3) TE on moles of O_2 Do not award incorrect unit e.g. dm^{-3} Correct answer with no working scores (3) Ignore SF except 1 SF Ignore use of $pV = nRT$	**(3)**

Q28.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following points (Justification) • two moles of chloride ions in aqueous solution so one mole of chloride ion is in the complex (1) • complex ion formula (1)	$[Cr(H_2O)_5(Cl)]^{2+}$	(2)

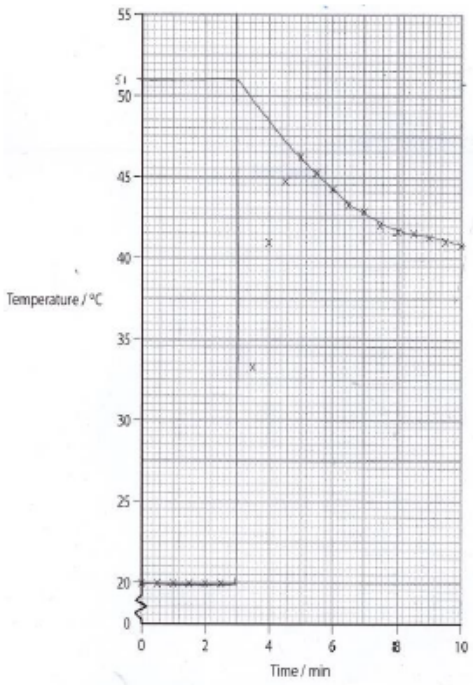
Q29.

Question number	Answer	Additional guidance	Mark
(a)(i)	• evaluation of number of moles of propanone (1) $= 0.025 \times 2.0 = 0.050$ mol • which is greater than the amount of iodine, which is $0.050 \times 0.020 = 0.0010$ mol (1)		2
(a)(ii)	• measuring cylinder/burette		1
(a)(iii)	• pipette		1
(b)	An explanation that makes reference to the following points: • the order with respect to iodine is zero (1) • because the graph is a straight line, showing that the change in iodine concentration is constant (1)		2
(c)	An answer that makes reference to the following points: • 1st order with respect to H^+ and propanone (1) • H^+ and propanone involved in reaction before rate determining step (therefore 1st order) (1) • iodine involved after rate determining step / slow step (therefore zero order) (1)		3

Q30.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• calculates mol of CO_2 and H_2O / mol C and H (1)	Example of calculation mol CO_2 / mol C = 0.88/44 = 0.02 and mol H_2O = 0.36/18 = 0.02 / mol H = 0.04	
	• deduces empirical formula (1)	ratio C : H = 1 : 2 and empirical formula is CH_2	
	• calculates mol **J** (1)	n = pV/RT mol **J** = 101 x 10^3 x 123 x 10^{-6}/(8.31 x 298) = 5.0166 x 10^{-3}	
	• calculates M_r of **J** and hence molecular formula (1)	M_r of **J** = 0.28/5.0166 x 10^{-3} = 55.8 so molecular formula is C_4H_8	**4**

Q31.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• suitable extrapolation (1) • ΔT in the range of 29 – 33(°C) (1)	Vertical at 3 minutes and smooth curve of best fit back from 10 minutes to 3 minutes  	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (i)	An explanation that makes reference to the following point: • as reaction is not instantaneous / takes time to release heat (1) • so some heat is lost as mixture heats up (1)		**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b) (ii)	An explanation that makes reference to the following points: • by using more finely powdered zinc (1) • because it will increase the rate of reaction (1)	A greater surface area of zinc Less time for heat loss	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	• Calculation of Q using Q = mcΔT (1) • amount of $CuSO_4(aq)$ (1) • energy per mol = Q/0.018 (1) • ΔH = -Q/1000 kJ mol^{-1} (1)	Using ΔT from (a) Example of calculation 25 x 4.18 x 30.5 = 3 187 (J) Allow 4.2 for 4.18 = 25/1000 x 0.720 = 0.018 3 187/0.018 = −177 kJ mol^{-1} / −180 kJ mol^{-1} / −177 000 J mol^{-1} / −180 000 J mol^{-1} Use of 4.2 gives −178 kJ mol^{-1} Must have correct sign and units for 4th mark	**4**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d) (i)	• (217 – answer to (c) / 217) x 100	Example of calculation (217 – 177 / 217) x 100 = 18.4%	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d) (ii)	An answer that makes reference to **two** of the following points: • no lid is used (1) • SHC of solution may not be 4.18 (1) • energy absorbed by zinc / energy absorbed by thermometer / polystyrene cup (1) • mass of solution is greater than 25 grams (1)	If answer in (c) is less negative than -217, points one and three are valid, and for point two candidates must state less than 4.18 for SHC If answer in (c) is more negative than -217, only point two can be awarded for candidates stating SHC is greater than 4.18 Do not award marks for just 'heat loss to surroundings'	**2**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d) (iii)	An explanation that makes reference to the following points: • ΔT would be less, so $\Delta_r H$ / enthalpy change calculated would be less negative (1) • because heat energy is transferred to greater volume of water than expected volume (1)		**2**

Q32.

Question Number	Correct Answer	Reject	Mark
(a)(i)	Mass of ethanoic acid = 0.04 x 60.1 = (2.404 g) **(1)** Volume of ethanoic acid = 2.404 ÷ 1.049 = 2.2917 = 2.3 (cm^3) **(1)** Correct answer with no working **(2)** Ignore SF except only one ALLOW 60.0 for molar mass which gives mass 2.4 and volume 2.288 = 2.3 cm^3 **(2)** OR First step 1.049 ÷ 60/60.1 to find number of moles in 1 cm^3 = 0.017 **(1)** Then volume = 0.04 ÷ 0.017 = 2.3529 (cm^3) But note, if whole calculation done on calculator, 60 gives 2.2879 and 61 gives 2.2917. **(1)** If units given, they must be correct, but penalise wrong units only once here.		**2**

Question Number	Correct Answer	Reject	Mark
(a)(ii)	Syringe ALLOW Burette Graduated/adjustable pipette	Gas syringe Biuret Just 'pipette'	**1**

Question Number	Correct Answer	Reject	Mark
(a)(iii)	To prevent... evaporation/vapour escaping water vapour entering OR To maintain a closed system OR To maintain a closed environment ALLOW To prevent: air oxidizing the alcohol reaction with air OR Due to volatility (of chemicals) IGNORE ...gas escaping ...HCl escaping		**1**

Question Number	Correct Answer	Reject	Mark
(a)(iv)	**First and second mark** Phenolphthalein **(1)** From colourless to (pale) pink/red **(1)** ALLOW Other indicators with pK_{in} in range 7.5 – 10 Some examples are: Thymol blue ((base)) (yellow to blue) Phen**ol** red (yellow to red) Thymolphthalein (colourless to blue) Second mark depends on correct indicator except bromothymol blue, which is incorrect but very close to range so allow colour yellow to blue. **Third mark** Sodium ethanoate is (slightly) alkaline OR Ethanoic acid is a weak acid OR Phenolphthalein pH range coincides with vertical section of the pH/titration curve	Litmus/universal indicator Pink to colourless Thymol blue **(acid)** Phenyl red Methyl red	**3**
	OR Titration of weak acid with strong base OR Neutralisation/equivalence point is at 8-10/ any number between 8 and 10. OR pK_{in} +/-1 lies within vertical region **(1)** Third mark is independent		

Question Number	Correct Answer	Reject	Mark
(b)(i)	$CH_3COOH+CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3+H_2O$ ALLOW Single arrow $-CO_2H$ $-C_2H_5$ Displayed formulae IGNORE state symbols even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
(b)(ii)	Volume of alkali reacting with ethanoic acid = 77.1-11.7 = 65.4 cm^3 **(1)** Moles of ethanoic acid = $\frac{65.4 \times 0.200}{1000}$ = $0.01308/1.308\times10^{-2}$ (mol) **(1)** Correct answer no working (2) Ignore SF except 1 Allow internal TE for use of Moles of ethanoic acid = $\frac{77.1 \times 0.200}{1000}$ = $0.01542/1.542\times10^{-2}$ (mol) max**(1)**		**2**

Question Number	Correct Answer	Reject	Mark
(b)(iii)	Number of moles of ethanol = $0.01308/1.308\times10^{-2}$ (mol) TE same as (ii)		**1**

Question Number	Correct Answer	Reject	Mark
(b)(iv)	Number of moles of ethyl ethanoate =0.0400−0.01308 = 0.02692 (mol) Allow TE from (ii)/(iii) for example 0.01542 gives 0.02458		**1**

Question Number	Correct Answer	Reject	Mark
(b)(v)	$K_c = \frac{[CH_3CO_2CH_2CH_3][H_2O]}{[CH_3CO_2H][\ CH_3CH_2OH]}$ **(1)** $= \frac{0.02692 \times 0.02692}{0.01308 \times 0.01308}$ = 4.23579 = 4.24 **(1)** Ignore SF except one Allow TE from (ii), (iii) and (iv) for example 0.01542 etc gives 2.54 No TE for incorrect expression of K_c		**2**

Question Number	Correct Answer	Reject	Mark
(b)(vi)	The units cancel OR There are the same numbers of moles of reactants and products		**1**

Question Number	Correct Answer	Reject	Mark
(b)(vii)	(Concentrated) hydrochloric acid contains water		**1**

Question Number	Correct Answer	Reject	Mark
(c)(i)	First test tube esterification OR addition/elimination ALLOW Condensation **(1)** Second test tube (acid) hydrolysis **(1)** Two fully correct answers in wrong order **(1) max**	Alkaline hydrolysis followed by acidification	**2**

Question Number	Correct Answer	Reject	Mark
(c)(ii)	The values are the same within experimental error OR The values are concordant ALLOW The values are similar **(1)** The equilibrium can be approached from either direction OR The reaction is reversible OR Any comment relating equilibrium to reversibility IGNORE Dynamic equilibrium OR Rate of reverse reaction = rate of forward reaction **(1)**	Just...the same	**2**

Question Number	Correct Answer	Reject	Mark
(c)(iii)	(Acid) catalyst (makes it faster) OR Provides H^+ (as a catalyst) OR Protonates... OR Protonating agent... OR Donates protons OR Increases H^+ concentration	Initiates Reacts with... Protates	**1**

Q33.

Question number	Answer	Additional Guidance	Marks
(a)	• axes: correct way round, labelled, suitable scale (1) • all points plotted correctly to nearest gridline AND straight line through first 3 points, straight line through last 3 points, and the two lines intersect (1)	The scale is suitable if the distance between the first point plotted and the last point plotted covers more than half of the graph paper on each axis.	**2**
(b)(i)	(0.005 x 0.5) = 2.5(0) x 10^{-3} / 0.0025 (mol)		**1**
(b)(ii)	10 (cm^3)	Award mark for a value read correctly from the candidate's graph	**1**
(b)(iii)	(0.010 x 1.00) = 1 x 10^{-2} / 0.01 (mol)	Answer to (iii) csq on (ii)	**1**
(b)(iv)	x = 4 and y = 2	Answer to (iv) csq on (i) and (ii), but x + y must total 6	**1**

Question number	Answer	Additional Guidance	Marks
(c)	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ • correctly balanced equation (1) • state symbols (1)	Allow $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(H_2O)_4(OH)_2(s) + 2H_2O(l)$	**2**

Q34.

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: • 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)** • 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 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) Allow only the concordant titres / titres 2 and 4 / 23.20 and 23.20 (cm^3) should be used / are used(in the mean) 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)	**(2)**

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)**

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)**	Example of calculation 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)**	<u>Example of calculation</u> 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)** • (this can be prevented by) placing a lid on the crucible **or** **(1)** heat more gently / carefully Not all water of crystallisation lost • less mass / mol /water is lost (than expected) **(1)** • (this can be prevented by) heating to constant mass **or** description of heating to constant mass **(1)** • so this accounts for the lower value of *z* / value of *z* decreases **(1)**	Ignore just 'loss in mass / mol' 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 Stand alone mark Ignore just 'heat for longer' Do not award the idea of repeating the experiment / using a drying agent Conditional on M3	(5)

Q35.

Question Number	Answer	Additional Guidance	Mark
(i)	• mass **and** temperature fall correct	Mass of $NaHCO_3$ used / g: 5.62 Temperature fall / °C: (−)6.6	(1)

Question Number	Answer		Additional Guidance	Mark
(ii)	• calculation of amount of $NaHCO_3$ **and** calculation of amount of hydrochloric acid	(1)	Example of calculation amount $NaHCO_3$ = 5.62 / (23 + 1 + 12 + (3 x 16)) = 0.0669 (mol) TE on mass of $NaHCO_3$ in (a)(i) **and** amount HCl = 50 x 2.00 / 1000 = 0.10 (mol) Ignore SF including 1SF Allow mol ratio = 1 : 1 so HCl is in excess Allow just more moles of HCl used Allow 0.10 > 0.0669 (mol) Allow HCl is in excess by 0.033 (mol)	(2)
	• 0.0669 mol $NaHCO_3$ needs 0.0699 mol HCl for reaction so HCl is in excess	(1)		

Question Number	Answer		Additional Guidance	Mark
(iii)	• calculation of heat absorbed	(1)	Example of calculation heat absorbed = 50.0 x 4.18 x 6.6 = 1379.4 (J) / 1.3794 (kJ) Ignore sign	(3)
	• calculation of enthalpy change	(1)	enthalpy change = 1379.4 / 0.0669 = 20619 (J mol^{-1}) **or** = 1.3794 / 0.0669 = 20.619 (kJ mol^{-1}) TE on heat absorbed and amount $NaHCO_3$ in (a)(ii)	
	• positive sign **and** units	(1)	Final answer +20.6(19) kJ mol^{-1} **or** +20619 J mol^{-1} TE on enthalpy change Allow +19.7(06) kJ mol^{-1} from 0.07 mol in (a)(ii) Allow kJ mol^{-} / J mol^{-} Ignore SF except 1 SF Ignore incorrect / missing units in M1 and M2 Correct answer with sign and units scores (3)	

Q36.

Question Number	Answer	Additional Guidance	Mark
(i)	• **(M1)** calculation of mole fractions **(1)**	Example of calculation X_{SO_2} = $0.0160 \div 0.8 = 0.02(0)$ $X_{O_2} = 0.0120 \div 0.8 = 0.015$ $X_{SO_3} = 0.772 \div 0.8 = 0.965$	**(5)**
	• **(M2)** calculation of partial pressures **(1)**	$P_{SO_2} = 0.02(0) \times 2.40 = 0.048$ $P_{O_2} = 0.015 \times 2.40 = 0.036$ $P_{SO_3} = 0.965 \times 2.40 = 2.316$	
	• **(M3)** expression of K_p **(1)**	$K_p = \frac{(P_{SO_3})^2}{(P_{SO_2})^2 \times P_{O_2}}$ Do not award square brackets	
	• **(M4)** calculation of value of K_p **(1)**	$K_p = \frac{2.316^2}{0.048^2 \times 0.036} =$ K_p= 64668.4..../6.46684.. x 10^4	
	• **(M5)** units **(1)**	K_p= 65000/6.5 x 10^4/64700/6.47 x 10^4 Ignore SF except 1 atm^{-1}	
		Correct final answer without working scores	(5)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of the number of molecules	Example of calculation N=(n x L = 0.0160 x 6.02 x 10^{23}) = 9.632 x 10^{21} Ignore SF except 1SF Do not award if any units are given	**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following points: • to ensure that K_p stays the same/ quotient stays the same **or** only temperature changes the value of K_p **(1)** • the number of (sulfur dioxide) molecules decreases **Either** because the equilibrium shifts to the right or because one of the denominators (oxygen) has increased so the other denominator (sulfur dioxide) has to decrease **(1)**	Standalone marks Allow concentration changes have no effect on the value of K_p Allow 'moles' for molecules	**(2)**

Q37.

Question Number	Answer	Mark
	The only correct answer is B (2.15×10^{22}) ***A*** *is not correct because the molar mass of carbon dioxide has been used in the calculation instead of that of carbon monoxide* ***C*** *is not correct because this is the number of molecules that are in one mole and not one gram of carbon monoxide* ***D*** *is not correct because this is the result of incorrectly using the molar mass of carbon monoxide rather than the number of moles of carbon monoxide*	**(1)**

Q38.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to: • electrons are excited/ promoted (by heat to higher energy levels / orbitals) **(1)** • electrons fall from the excited state (to their ground state/to lower energy levels) **(1)** • electrons release energy/photons as (visible) light/ in visible region **(1)**	Lack of reference to 'electrons' results in a maximum of (2) for an otherwise correct answer Allow raised/jump/moved up for 'excited' Allow return/drop/de-excite for 'fall' Allow Wavelength/ frequency/ radiation for 'energy' Do not award reflected for 'release' Do not award colour for 'energy'	**(3)**

Q39.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$	Allow multiples Ignore state symbols	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
***(ii)**	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5–4 / 3 3–2 / 2 1 / 1 0 / 0 The following table shows how the marks should be awarded for structure and lines of reasoning.	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured	

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Indicative Content:

- V_2O_5 acts as a heterogeneous catalyst
- SO_2 is adsorbed onto surface and reacts with the V_2O_5
- SO_3 forms and is only weakly bonded to surface
- the SO_3 desorbs from the surface
- oxygen reacts with the VO_2, regenerating the V_2O_5 catalyst
- reaction follows different mechanism with lower activation energy

with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

Ignore comments related to collision theory

6

Q40.

Question Number	Answer	Additional Guidance	Mark
	• molar mass of hydrated copper(II) sulfate **(1)** • mass of 0.0250 mol hydrated copper(II) sulfate **(1)**	Example of calculation $M_r(CuSO_4.5H_2O)$= 249.6 (g mol^{-1}) m($CuSO_4.5H_2O$)= 6.24 (g) Answer to 2 / 3SF Correct answer with no working scores (2) TE from incorrect M_r	**(2)**

Q41.

Question Number	Answer	Additional Guidance	Mark
	• **M1** conversion of pressure and temperature (1) • **M2** conversion of volume units (1) • **M3** rearrangement of gas equation and calculation of *n* (1) • **M4** calculation of the molar mass with the final answer given to **2 or 3 SF** (1)	Example of calculation 118 000 (Nm^{-2}) and 438 (K) 70.5×10^{-6} / 7.05×10^{-5} (m^3) $n = \frac{pV}{RT}$ $n = \frac{(118000 \times 70.5 \times 10^{-6})}{(8.31 \times 438)}$ $n = 2.2855777 \times 10^{-3}$ (mol) $\frac{0.271}{2.2855777 \times 10^{-3}}$ = 118.5696 = 119 / 120 (g mol^{-1}) If use $M_r = \frac{mRT}{pV}$ (since $n = \frac{m}{M_r}$) can score both **M3 and M4** $M_r = \frac{0.271 \times 8.31 \times 438}{118\,000 \times 70.5 \times 10^{-6}}$ M_r = 118.5695 M_r = 119 / 120 (g mol^{-1}) Award TE at each stage Ignore units even incorrect	**(4)**

Q42.

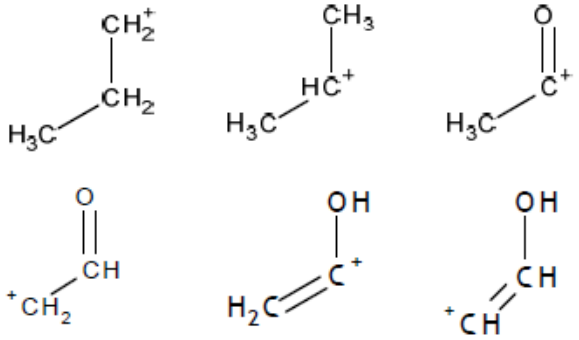
Question Number	Acceptable Answers	Reject	Mark
(a)(i)	So that only the water formed in the combustion is absorbed by X / measured. ALLOW 'reacts with X' for 'absorbed by X' OR Otherwise the mass / amount of the water measured will be too high	Reacts with A References to Y	**1**

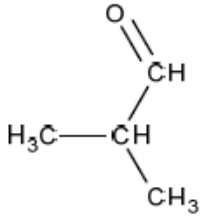
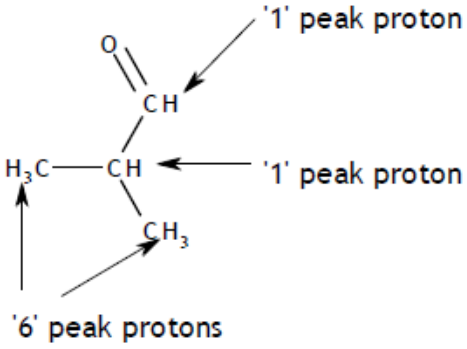
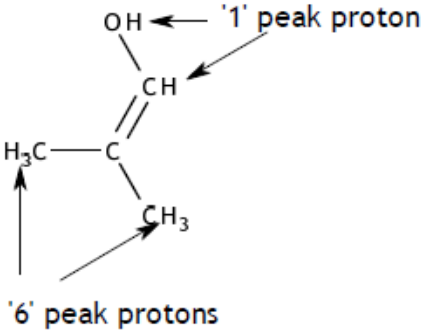
Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	(Anhydrous) Calcium chloride / $CaCl_2$ / Magnesium sulphate / $MgSO_4$ / silica gel / sodium sulphate / Na_2SO_4 ALLOW Phosphorus(V) oxide / phosphorus pentoxide / P_4O_{10} / P_2O_5 / Silica beads	Sulfuric acid Calcium oxide Silica / SiO_2 anhydrous copper(II) sulfate	**1**

Question Number	Acceptable Answers	Reject	Mark
(a)(iii)	Soda lime OR calcium hydroxide / $Ca(OH)_2$ **and** sodium hydroxide / NaOH ALLOW sodium hydroxide / NaOH / potassium hydroxide / KOH / Calcium oxide / CaO	Limewater	**1**

Question Number	Acceptable Answers	Reject	Mark
(a)(iv)	The methods below illustrate the allocation of marks. But the first four marks may be scored by any correct method. **Method 1** mol CO_2 = 8.8/44 = 0.2 (= mol C) **(1)** mol H_2O = 3.6/18 = 0.2 mol H = 2 x mol H_2O = 0.4 **(1)** mass O = 3.6 – (12 x 0.2 + 1 x 0.4) = 0.8 (g) **(1)** mol O = 0.8/16 = 0.05 **(1)** **Method 2** Mass H = 3.60 x 2/18 = 0.40 (g) = 0.40 / 1 = 0.40 (mol) **(1)** Mass C = 8.80 x 12/44 = 2.4 (g) = 2.4 / 12 = 0.20 (mol) **(1)** Mass O = 3.60 – (0.40 + 2.4) = 0.80(g) **(1)** = 0.80 / 16 = 0.05 (mol) **(1)**		**5**
	Empirical formula = C_4H_8O **(1)** TE on incorrect moles but the ratio **must** be whole number IGNORE use of O_2 for O in the 'words' Correct empirical formula with some working at each stage scores full marks **but** Correct empirical formula with **no** working or **unclear and non-scoring** working scores final mark only		

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	(Molecular ion is m/e =) 72 (= M_r of **A**)**(1)** Molecular formula = C_4H_8O **(1)** No TE on incorrect molecular ion	Structural Or Displayed Or Molecular ion	**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	Any three of (1 mark for each structure)  ALLOW structural formulae (eg CH_3CO^+) IGNORE Position of positive charge Penalise omission of charge or negative charge once $C_3H_7^+$ and /or $C_2H_3O^+$ scores 1 if no scoring structure		**3**

Question Number	Acceptable Answers		Reject	Mark
***(c)**	Structure of **A** (1)  Three (proton/H) environments (1) **Identify** the 6 protons in one environment and 1 each in the other two (1) No TE on incorrect structures except propan-2-ol : scores MP3 only	OR diagram (1)  6 proton label (1) **both** 1 proton labels (1) ALLOW enol structure  6 proton label (1) **both** 1 proton labels (1)		**3**

Q43.

Question Number	Correct Answer	Reject	Mark
(a)(i)	Purple gas/ gas turns colourless **(1)** to (silver/shiny) grey/black solid **(1)** **Just** gas to solid OR solid forming **(1)max**	Purple liquid/solid	2

Question Number	Correct Answer	Reject	Mark
(a)(ii)	**First mark** Heat for different lengths of time OR After more time/specified time eg 2 days .... OR Use a colorimeter OR Set up reverse reaction **(1)** **Second mark** Measure the concentration of a reactant or product of two tubes, which should be the same OR Colour does not change /is same **(1)**		2

Question Number	Correct Answer	Reject	Mark
***(b)(i)**	Equilibrium moles HI $\frac{30 \times 0.00353}{1000} = 0.0001059$ **(1)** H_2 and I_2 $\frac{30 \times 0.00048}{1000} = 0.0000144$ **(1)** Initial amount of HI = 0.0001059 + 2 x 0.0000144 = 0.0001347 (mol) ALLOW TE from wrong moles of either or both entity **(1)** Mass of 1 mol of HI = 127.9 **(1)** Mass of HI = 0.0001347 x 127.9 = 0.0172 g **(1)** Correct answer with or without working **(5)** All marks stand alone Last two marks are available for **any** amount in moles x 127.9correctly calculated		5

Question Number	Correct Answer	Reject	Mark
(b)(ii)	$K_c = \frac{[H_2][I_2]}{[HI]^2}$ Ignore state symbols unless (aq) or (s) Ignore eq or eqm	p H_2 etc (K_p)	1

Question Number	Correct Answer	Reject	Mark
(b)(iii)	$K_c = \frac{0.00048 \times 0.00048}{0.00353^2}$ $= 0.018489$ $= 0.0185$ Allow all SF except 1		1

Question Number	Correct Answer	Reject	Mark
(b)(iv)	The units cancel OR There are the same numbers of moles of reactants and products		1

Question Number	Correct Answer	Reject	Mark
(c)(i)	$K_c' = \frac{[H_2]^{½}[I_2]^{½}}{[HI]}$ Ignore state symbols unless (aq) or (s) Ignore eq or eqm	p H_2 etc (K_p) but not if already penalised	1

Question Number	Correct Answer	Reject	Mark
(c)(ii)	$K_c' = \frac{[0.00048]^{½}[0.00048]^{½}}{[0.00353]}$ $= 0.136$ Allow all SF except 1 **(1)** Which is the square root of the previous value OR $K_c = (K_c')^2$ OR $0.136^2 = 0.0185$ **(1)**		2

Question Number	Correct Answer	Reject	Mark
(d)	**Frist mark** K_p remains unchanged/constant **(1)** **Second mark** (when pressure is increased) the quotient/ratio p_{H2}: $(p_{HI})^2$ becomes less than *K*p OR Ratio decreases OR Ratio proportional to 1/P (P is total pressure change) ALLOW K_p proportional to 1/P **(1)**	K_p decreases for this mark only	3
	Third mark To restore the value of the quotient/ratio to *K*p ALLOW To restore *K*p **And** EITHER p_{H2} increases / p_{HI} decreases **(1)** OR Equilibrium shifts to the right **(1)**		

Q44.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• calculation of gradient of straight line **(1)** • numerical value of E_a **(1)** • sign and units **(1)**	Example of calculation Gradient = −19500 Allow ±500 $-E_a$ = −19500 x 8.31 / 1000 = 162 ± 5 + **and** kJ mol^{-1} Accept +162000 **Jmol^{-1}** Final answer with or without working scores (3) Allow TE for incorrect gradient as long as the final value is not negative Ignore SF except 1SF	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • (Reason) anomalous point	Allow description of Allow 'outlier'	**(1)**

Q45.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	• MnO_2, MnO_4^-, OH^- and MnO_4^{2-} species correct in a single equation **(1)** • H_2O on right **and** balancing **(1)**	Example of equation $MnO_2 + 2MnO_4^- + 4OH^- \rightarrow 3MnO_4^{2-} + 2H_2O$ Ignore state symbols, even if incorrect Do not award M1 if H^+ is on the left Allow cancelled electrons Allow multiples	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	An answer that makes reference to: • 2 different species are oxidised and reduced (to form the same species) **or** there is not 1 species that is being oxidised and reduced **or** 2 different oxidation states are not produced from one oxidation state **or** only 1 oxidation state / +6 is formed as a product **or** Mn changes from +4 and +7 to +6 (only)	This mark can be awarded even if (i) is incorrect Allow manganate(VI) / MnO_4^{2-} is oxidised and reduced in the reverse reaction Allow Mn in the same species is not being oxidised and reduced Ignore just 'Mn is not simultaneously oxidised and reduced' Ignore this is reverse disproportionation / comproportionation Do not award O / H is oxidised / reduced Do not award molecules / compounds for species	(1)

Q46.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• correct equation	Example of equation $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ Allow multiples Allow Na^+ on both sides if crossed through Ignore state symbols even if incorrect	(1)

Q47.

Question Number	Answer	Additional guidance	Mark
(a)	• $C_6H_5COOH + CaO \rightarrow C_6H_6 + CaCO_3$	Accept $C_6H_5COOH + CaO \rightarrow C_6H_6 + CaO + CO_2$	1
(b)	An answer that makes reference to the following points: • -2 in cyclohexane and -1 in benzene (1) • so (carbon is) oxidised (1)	2nd mark stands alone	2

Q48.

Question Number	Answer	Additional Guidance	Mark
(i)	• (The cation in **X** is) Fe^{2+} / iron(II) / Fe(II) (1) • (The anion in **X** is) SO_4^{2-} / sulfate(VI) (1)	Allow Fe^{+2} Allow sulfate / SO_4^{-2} Do not award sulfite / sulfate(IV)	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	• species and balancing (1) • state symbols (1)	Examples of equation $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ **or** $[Fe(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s) + 6H_2O(l)$ **or** $[Fe(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(H_2O)_4(s) + 2H_2O(l)$ Ignore missing square brackets TE on cation that forms an insoluble hydroxide in **Test 1** State symbols conditional on correct species or 'near miss' / non-ionic equation	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following point: • Fe^{2+} is oxidised (to Fe^{3+}) by oxygen / air	Allow iron(III) hydroxide / iron(III) (ions) are formed by reaction with oxygen / air TE on cation in **Test 1** Allow just 'the precipitate / it is oxidised by oxygen / air'	(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	An answer that makes reference to the following point: • to react with / remove any carbonate / sulfite / sulfate(IV) ions **or** to eliminate the possibility of carbonate / sulfite / sulfate(IV) ions	Allow to prevent any other ions forming a precipitate with barium ions / Ba^{2+}	(1)

Q49.

Question Number	Answer	Additional Guidance	Mark
(i)	• ionic equation (1) • state symbols (1)	Example of equation $Ag^{+}(aq) + I^{-}(aq) \rightarrow AgI(s)$ Allow multiples M2 dependent on M1 or near miss	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that includes • halide ion with some justification attempt (1) • calculation of expected mass of silver halides (1)	Incorrect halide scores (0) Bromide (ion)/Br^{-} Do not award 'bromine (ion)' 0.01 mol of AgCl = 1.43 (g) AgBr = 1.88 (g) AgI = 2.35 (g) OR Mass of 1.0 mol is 188 g so subtraction of 107.9 for Ag means X = 80.1 so closest is Br TE on incorrect formula silver halide in d(i)	(2)

Q50.

Question Number	Answer	Additional Guidance	Mark
	• calculation of moles of Br_2 **(1)** • calculation of moles of limonene **(1)** • calculation of mass of limonene **(1)** • calculation of percentage of limonene **and** answer given to 2 or 3 SF **(1)**	Example of calculation moles of Br_2 = $\frac{30.6 \times 0.200}{1000}$ = 0.00612 / 6.12×10^{-3} moles of limonene = $\frac{0.00612}{2}$ = 0.00306 / 3.06×10^{-3} TE on moles of Br_2 molar mass of limonene = 136 (g mol^{-1}) **and** mass of limonene in oil = 0.00306 x 136 = 0.41616 (g) TE on moles of Br_2 percentage of limonene = $\frac{0.41616}{0.500} \times 100$ (= 83.232(%)) = 83/83.2(%) TE on mass of limonene provided answer is less than 100% with 0.500 as denominator Correct answer with no working scores (4)	**(4)**

Q51.

Question Number	Answer	Additional Guidance	Mark
	• calculation of molar mass of methyl cinnamate (1) • calculation of mass of carbon (1)	Example of calculation molar mass = 162 (g mol^{-1}) 2.34 x (120/162) = 1.73333 = 1.73 (g) TE on incorrect molar mass for M2 **Correct answer with no working scores 2 marks** Ignore SF except 1	**(2)**

Q52.

Question Number	Acceptable Answers	Reject	Mark
(a)	Oxygen atoms in water molecules have δ− charge. **(1)** Which form electrostatic / ion-dipole attractions with sodium (ion). **(1)** ALLOW for one mark copper(II) ions form dative covalent bonds but sodium ions do not (**both** needed)	 Ionic bonds / attractions Intermolecular forces Hydrogen bonds	**2**

Question Number	Acceptable Answers	Reject	Mark
(b)	Additional (dative covalent bond) lone pairs are accommodated in vacant (3)d orbitals / (3)d sub-shell ALLOW Vacant **higher** energy orbitals / sub-shells IGNORE 3s/3p	'Partially filled' for 'vacant'	**1**

Question Number	Acceptable Answers	Reject	Mark
*** (c)(i)**	(3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy (d orbital(s) / levels) ALLOW d—d transitions occur /electrons are excited **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell is split Emitted	**4**

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	Zn (3)d orbitals are / (3)d subshell is **full / complete** (so d–d transitions are not possible) / Zinc is $3d^{10}$	Zn does not have partially filled d subshell	**1**

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	(d–d) energy gap is large **(1)** the energy absorbed is outside the visible region / in the UV region **(1)** Stand alone marks		**2**

Question Number	Acceptable Answers	Reject	Mark
(d)	**<u>Method 1: cell emfs</u>** For the reaction $Cu(H_2O)_6^{2+}(aq) + 2S_2O_3^{2-}(aq)$ $\rightarrow Cu(s) + 6H_2O(l) + S_4O_6^{2-}(aq)$ * $E^{\circ}_{cell} = +0.34 - 0.09 = (+)0.25$ (V) **and** (Positive so) reaction is feasible **(1)** For the reaction $Cu(H_2O)_2(NH_3)_4^{2+}(aq) + 2S_2O_3^{2-}(aq)$ $\rightarrow Cu(s) + 2H_2O(l) + 4NH_3(aq) + S_4O_6^{2-}(aq)$ ** $E^{\circ}_{cell} = -0.05 - 0.09 = -0.14$ (V) **and** (Negative so) reaction is not feasible **(1)** If both values correct but feasibility omitted or incorrect award 1 mark **Both** equations (* & **) correct IGNORE Omission of H_2O and states from the equations **(1)**	electrons in equations	**3**

Method 2: anticlockwise rule

Place the reactions in order of increasing (more positive) $E^{\ominus}$ values and check which reaction occurs in the anticlockwise direction. **(1)**

$S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$ $E^{\ominus} = +0.09$ V

$Cu(H_2O)_6^{2+}(aq) + 2e^- \rightarrow Cu(s) + 6H_2O(l)$ $E^{\ominus} = 0.34$ V

Reaction is feasible (desired reaction proceeds in anticlockwise direction) **(1)**

$Cu(H_2O)_2(NH_3)_4^{2+}(aq) + 2e^- \rightarrow Cu(s) + 2H_2O(l) + 4NH_3(aq)$ $E^{\ominus} = -0.05$ V

$S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$ $E^{\ominus} = +0.09$ V

Reaction is not feasible (proceeds in the opposite direction). **(1)**

Question Number	Acceptable Answers	Reject	Mark
(e)(i)	(coordination number =) 4 / four		**1**

Question Number	Acceptable Answers	Reject	Mark
(e)(ii)	Amount of complex = 4.82 / 288.7 (= 0.0166955 mol) Mass of nickel = 58.7 x 4.82 / 288.7 = 0.98003 g **(1)** % Nickel in alloy = 100 x 0.98 / 1.02 = 96.08 % **(1)** Correct answer with no working scores 2 Ignore SF except 1 ALLOW TE unless %>100 Use of A_r(Ni) = 59 (gives 96.57%)		**2**

Q53.

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 9.375×10^{-3} / 9.38×10^{-3} / 9.4×10^{-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)

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	Example of equation: $MCO_3(s) \rightarrow MO(s) + CO_2(g)$ 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)**

Q54.

Question number	Acceptable Answer	Additional Guidance	Marks
(a)	• use of 1:8 ratio in kg, grams or moles (1) • calculating mass of lithium (1) • answer to two or three sf (1)	<u>Example of calculation:</u> 146.1 kg of SF_6 react with (8 x 6.90) 55.2 kg of Li ∴ 398 kg of SF_6 react with $\frac{55.2}{146.1}$ × 398 kg = 150(.3737.....) kg of Li 150 (kg) Final answer must be to two/three significant figures Correct final answer to two/three significant figures with no working scores (3)	**3**

Question number	Acceptable Answer	Additional Guidance	Marks
(b)	• calculating $\Delta S^{\ominus}_{system}$ (1) • calculating $\Delta S^{\ominus}_{surroundings}$ (1) • conversion of units to be the same (1) • calculating $\Delta S^{\ominus}_{total}$ with units (1)	<u>Example of calculation:</u> $\Delta S^{\ominus}_{system}$ = 63.0 + (6 x 35.6) – 292 – (8 x 29.1) = –248.2 (J K^{-1} mol^{-1}) $\Delta S^{\ominus}_{surroundings} = -\frac{-2\,934\,000}{298}$ = +9845.638 (J K^{-1} mol^{-1}) Accept 9850 (J K^{-1} mol^{-1}) Accept 9.846 kJ K^{-1} mol^{-1} $\Delta S^{\ominus}_{total}$ = +9597 J K^{-1} mol^{-1} Accept any number of significant figures up to and including the calculator value of 9597.437584 Correct answer with units and no working scores 4	**4**

Question number	Acceptable Answer	Additional Guidance	Marks
(c)	An answer that makes reference to the following points: • $\Delta S^{\ominus}_{total}$ is positive, so the reaction is (thermodynamically) feasible (1) • therefore (if it needs a fuse), it must have a high activation energy (1)		**2**

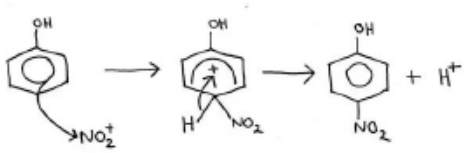
Q55.

Question Number	Answer	Additional Guidance	Mark
	$C_{15}H_{14}O_2$	Allow symbols in any order e.g. $H_{14}O_2C_{15}$	**(1)**

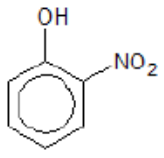
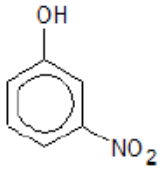
Q56.

Question Number	Acceptable Answers	Additional Guidance	Mark
	An answer that makes reference to the following points: **mixing of 1st pair of solutions** • mix Br_2 with KCl **(1)** **mixing of 2nd pair of solutions** • mix Br_2 with KI **or** mix I_2 with KBr **(1)** **colours of halogen (in cyclohexane)** • colour seen for experiment 1/ bromine is orange / yellow **and** colour seen for experiment 2/ iodine is purple / pink / violet / lilac **(1)** **correct ionic equation** • $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ **(1)** • use of ONLY two correct experiments as above **(1)**	Ignore any reference to any additional reactions, e.g. with silver nitrate Award mark if correct ionic equation is given Ignore colours before the addition of cyclohexane Do not award brown Do not award red Allow multiples Ignore state symbols even if incorrect	**(5)**

Q57.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An answer that makes reference to • Electron pair movement from ring to electrophile **(1)** • Formula of intermediate ion **(1)** • Curly arrow from C-H bond to reform delocalised ring and correct final structure with H^+ also formed **(1)**	Allow arrow that starts from anywhere within the hexagon but it must go to the nitrogen of the ion 'Horseshoe' to cover at least three carbon atoms, facing the tetrahedral carbon and part of the + sign to be inside the 'horseshoe' Do not award '+' charge on the tetrahedral carbon Do not award dotted bonds unless part of a 3D structure Curly arrow to go from the bond to anywhere inside the ring Accept the drawing of HSO_4^- to remove the H from the ring as long as H_2SO_4 is given as the product instead of H^+ Exemplar mechanism  Do not penalise attachment of OH/NO_2 to benzene ring Penalise incorrect product: 1 mark	**(3)**

Question Number	Acceptable Answer	Mark
(ii)	The only correct answer is **B** ***A*** *is incorrect because this is 15% of the mass of the starting material* ***C*** *is incorrect because this is the percentage of the starting mass over the max mass of product* ***D*** *is incorrect because this is 100% yield and not 15%*	**(1)**

Question Number		Additional Guidance	Mark
(iii)	 **and** 	Ignore connectivity of OH/NO_2	**(1)**

Q58.

Question Number	Answer	Additional Guidance	Mark
(i)	• chlorine is oxidised **and** from 0 to +1 (in NaClO) **(1)** • chlorine is reduced **and** from 0 to -1 (in NaCl) **(1)**	Check the equation Allow (1) for three correct oxidation numbers if no other mark is awarded. Allow (1) max for general definition of disproportionation	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• equation	$6\,NaOH + 3\,Cl_2 \rightarrow NaClO_3 + 5\,NaCl + 3\,H_2O$ Allow multiples	(1)

Question Number	Answer	Mark
(iii)	**The only correct answer is C** (hot alkali) **A** *is not correct because high temperature is required* **B** *is not correct because high temperature is required* **D** *is not correct because high temperature and not excess chlorine is required*	(1)

Q59.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	$C_5H_{12}O + [O] \rightarrow C_5H_{10}O + H_2O$ • left-hand side of equation correct **(1)** • right-hand side of equation correct **(1)**	**Molecular** formulae must be used throughout Allow [O] above the arrow Do not award for $C_5H_{11}OH$ as the alcohol Ignore state symbols if incorrect or conditions mentioned	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• calculation of moles of both of $C_5H_{10}O$ and $C_5H_{12}O$ **(1)** • calculation of mass of $C_5H_{12}O$ **(1)** OR • calculation of theoretical mass of $C_5H_{10}O$ **and** moles of $C_5H_{10}O$ **(1)** • calculation of mass of $C_5H_{12}O$ **(1)**	Example of calculation Moles $C_5H_{10}O = \frac{2.15}{86.0} = 0.025(0)$ (mol) **and** moles $C_5H_{12}O = \frac{0.025(0)}{62.5} \times 100 = 0.04(00)$ (So) mass of $C_5H_{12}O = 0.04(00) \times 88 = 3.52$ g Theoretical mass $C_5H_{10}O = \frac{2.15}{62.5} \times 100 = 3.44$ g **and** moles $C_5H_{10}O = \frac{3.44}{86.0} = 0.04(00) =$ mol $C_5H_{12}O$ (So) mass of $C_5H_{12}O = 0.04(00) \times 88 = 3.52$ g Correct answer with no working scores (2) Allow TE from MP1 Award 1 mark for 3.36 g, 1.375 g or 2.2 g	**(2)**

Q60.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• calculation of M_r of phenylethene **(1)** • answer converted into percentage to 2 or 3 SF **(1)**	Example of calculation: (M_r of phenylethene = 104 % = (96 ÷ 104 x 100 = 92.30769..%) =92 (%)/92.3 (%) Allow TE on incorrect M_r as long as answer not >100% Correct answer without working scores (2)	**(2)**

Q61.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	An answer that makes reference to the following points: • cool the mixture because the reaction (with concentrated sulfuric acid / H_2SO_4) is (very) exothermic / releases (a lot of) heat **(1)** • anti-bumping granules are added to prevent violent / sudden / localised boiling **or** to prevent superheating / large bubbles forming **or** to promote smooth / even / controlled boiling **or** to promote the formation of small bubbles **or** to provide nucleation centres / (rough) surface for bubble formation **(1)** • heating under reflux is used to prevent the loss of any volatile substances / volatile reactants / volatile products / organic compound / named organic compound **or** to make sure the vapour / gas condenses **or** to prevent vapour escaping **(1)**	Ignore reaction is violent / to prevent splashing / to slow down the reaction / to stop reactants evaporating Do not award to quench the reaction / reference to explosion Ignore to stop bumping / spitting / explosion / liquid splashing out / vigorous reaction / loss of reactants / to distribute heat more evenly / any reference to rate / to promote smooth heating Allow so that the reaction goes to completion Ignore just 'to prevent gas escaping' / just 'to prevent loss of reactants / products' / just 'reactants / products are volatile' / 'because 1-bromobutane / butan-1-ol is flammable' / to increase yield / reference to safety Do not award for reference to oxidation or reduction	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following points: • there is a gap between the condenser and the flask / seal the joint between the flask and condenser **and** so vapour / gas / reactants / products will escape **(1)** • the water is flowing the wrong way through the condenser / the water should go in at the bottom (and out at the top) **and** so it doesn't fill with water / is only part filled /there is an airlock **(1)** • there is a stopper on the condenser / there should not be a stopper on the condenser **and** so there will be a build-up of pressure (if the gap between condenser and flask is closed) **(1)**	Allow answers shown on annotated diagram e.g. gap circled Ignore any additional errors Ignore additional suggested modifications even if incorrect Do not award just 'the apparatus is not sealed' unless it is clear it means between the condenser and flask Allow so this will lower the yield of product / 1-bromobutane Ignore condenser is fitted the wrong way up Allow so there will be inefficient condensation / cooling Allow so the stopper will blow off / there will be an explosion / it will be dangerous	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(iii)	An explanation that makes reference to the following points: • (brown vapour / it) is bromine / Br_2 **(1)** • bromide ions / Br^- / HBr oxidised (by concentrated sulfuric acid) **(1)**	Stand alone mark Do not award just 'Br' Do not award any other brown gas in addition to bromine Allow bromide ions / Br^- / HBr reduce sulfuric acid / act as a reducing agent Ignore sodium bromide / NaBr is oxidised Ignore just 'redox reaction' Do not award bromine is oxidised Do not award oxidation by anything other than sulfuric acid	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(i)	An answer that makes reference to the following: • aqueous layer is on the top **and** because water / it has a lower density than 1-bromobutane	Allow 'it' for aqueous layer Allow because 1-bromobutane has a higher density than water Ignore reference to butanol unless in a third layer Do not award water is 'lighter' Do not award reference to three layers	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(ii)	An answer that makes reference to the following points: Step **8** • (aqueous sodium hydrogencarbonate / $NaHCO_3$) reacts with / neutralises / removes the (hydrochloric) acid / H^+ (ions) in the mixture **(1)** Step **9** • (the tap is opened) to release the carbon dioxide / gas (formed) **or** to allow the carbon dioxide / gas to escape **or** to prevent the build-up of pressure **(1)** Step **10** • (anhydrous sodium sulfate is added) to remove / absorb water **(1)**	Do not award reacts with incorrect acid e.g. H_2SO_4 / HBr / ethanoic acid Ignore removes water Do not award an incorrect gas e.g. hydrogen Allow (anhydrous) sodium sulfate is a drying agent / added to dry the product Do not award dehydration / reacts with water	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iii)	• starting temperature 99 or 100 or 101 (°C) **and** final temperature 103 or 104 or 105 (°C)	Do not award just one value / 102 (°C) Do not award 102 (°C) with another temperature	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)(iv)	• calculation of mol of 1- bromobutane **(1)** • calculation of number of molecules **and** answer to 2/3 SF **(1)**	Example of calculation mol of 1-bromobutane = $\frac{12.0 \times 1.27}{136.9}$ = 0.11132 (mol) Do not award 0.1 number of molecules = $0.11132 \times 6.02 \times 10^{23}$ = 6.7×10^{22} / 6.70×10^{22} TE on a calculated mol 1-bromobutane using M_r Correct answer to 2 or 3 SF with no working scores (2)	**(2)**

Q62.

Question Number	Answer	Additional Guidance	Mark
(i)	• amount of sodium thiosulfate (1) • amount of liberated iodine (1)	Example of calculation amount of sodium thiosulfate = 21.2/1000 x 0.500 = 0.0106 (mol) amount of liberated iodine = 0.0106/2 = 5.3×10^{-3} /0.0053 (mol) Allow ecf from 1st to 2nd mark Correct answer with no working scores 2 marks	**2**
(ii)	• initial amount of ICl (1) • amount of ICl that reacted with oil (1) • mass of iodine in ICl (1) • expression for iodine value (1) • final iodine value (1)	Allow ecf from (b)(i) If no subtraction allow 3 max (1st, 4th and 5th marks) Example of calculation Initial amount of ICl = 11.0 /162.4 = 0.067734 (mol) Amount of ICl that reacted with oil = $0.067734 - 5.3 \times 10^{-3}$ = 0.062434 (mol) Mass of iodine in ICl = 0.062434 x 126.9 =7.9229s g (with 6.4 g oil) iodine value = 7.9229 x 100/6.4 = 123.79 / 124 Correct answer with no working scores 5 marks	**5**

Q63.

<table>
<tr><th>Question number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Marks</th></tr>
<tr>
<td>* (iii)</td>
<td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td></td>
</tr>
</table>

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The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2
Answer is partially structured with some linkages and lines of reasoning.	1
Answer has no linkages between points and is unstructured.	0

Indicative content

Similarity

	• reaction is between Mg and H^+ / $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$	both acids produce one H^+ / are monobasic / are monoprotic	**6**
	• 100 cm^3 of HCl and 100 cm^3 HCOOH contain the same initial number of moles of the acid	the same volume <u>and</u> concentration of both acids is used	
	• therefore same total volume of gas evolved	a calculation to show the same volume	
	Difference		
	• HCl is fully dissociated/ionised but HCOOH only partially dissociated/ionised	dissociation/ionisation of HCOOH requires energy	
	• $[H^+]$ is greater in HCl / $[H^+]$ is smaller in HCOOH		
	• therefore rate is greater with HCl / lower with HCOOH	therefore larger activation energy with HCOOH	

Q64.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(i)	correct equation	Example of equation: $2NaN_3 \rightarrow 2Na + 3N_2$ Allow multiples Ignore state symbols even if incorrect	(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	• conversion of volume and temperature to correct units **(1)** • rearrangement of ideal gas equation so $n=pV \div RT$ and calculation of $n(N_2)$ in moles **(1)** • evaluation of $n(NaN_3)$ **(1)** • answer converted into mass to 2/3 SF **(1)** Allow TE at each stage	Example of calculation: 67 dm^3 = 0.067 m^3, 300°C = 573 K $n(N_2) = \frac{140\,000 \times 0.067}{8.31 \times 573}$ = = 1.9699.....(mol) $n(NaN_3)$ = (2/3 x 1.9699.....=) 1.313....(mol) m= (1.313 .... x 65 = 85.3629..=) = 85.4 / 85 (g) Correct answer without working scores (4)	(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	An answer that makes reference to the following points: • Nitrogen (is reduced) from +5 to 0 **(1)** • Sodium (is oxidised) from 0 to +1 **(1)** • Balanced equation **(1)**	Look for oxidation numbers annotated on the equation Do not award potassium oxidised Penalise omission of "+" sign, once only Example of balanced equation: **10**Na +**2**$KNO_3 \rightarrow K_2O$+ **5**$Na_2O + N_2$ Allow multiples	(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	An answer that makes reference to the following points: • Neutralisation reaction / acid base reaction **(1)** • Sodium and/or potassium oxides are caustic / corrosive **(1)** • Salts (silicates) formed are inert / unreactive **(1)**	Allow salt formation Allow "metal oxides" Ignore "harmful" / "alkaline" Allow "not harmful"/ "not caustic" Ignore "neutral"	(3)

Question Number	Acceptable Answer	Mark
(d)	The only correct answer is **A** ***B*** *is incorrect because the peak would shift to the left and be higher* ***C*** *is incorrect because the peak would shift to the left not to the right* ***D*** *is incorrect because the peak would be shift to the left not to the right*	**(1)**

Q65.

Question Number	Acceptable Answers	Reject	Mark
(a)(i)	$Fe^{2+} \rightarrow Fe^{3+} + e^{(-)}$ $½O_2 + 2H^+ + 2e^{(-)} \rightarrow H_2O$ OR $O_2 + 4H^+ + 4e^{(-)} \rightarrow 2H_2O$ ALLOW Reversible arrows Equations in other direction Electrons subtracted on LHS of first equation Multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	$½O_2 + 2H^+ + 2Fe^{2+} \rightarrow 2Fe^{3+} + H_2O$ OR $O_2 + 4H^+ + 4Fe^{2+} \rightarrow 4Fe^{3+} + 2H_2O$ ALLOW Multiples Reversible arrows Ignore state symbols even if incorrect No TE from 20(a)(i)	Equation in the wrong direction, even with reversible sign	1

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	(Pale) pink	Purple / mauve	1

Question Number	Acceptable Answers	Reject	Mark
***(b)(iii)**	Amount of MnO_4^- = 24.90 x 0.0195 x 10^{-3} = 4.8555 x 10^{-4} (mol)* **(1)** Amount of Fe^{2+} = answer * x 5 in 25 cm^3 = 4.8555 x 10^{-4} x 5 = 2.42775 x 10^{-3} (mol) So in 250 cm^3 = 2.42775 x 10^{-2} (mol) **(1)** (M_r ($FeSO_4.7H_2O$) = 277.9) **ROUTE 1 (via moles)** Amount of Fe^{2+} used to prepare the solution = 6.90 / 277.9 = 2.4829 x 10^{-2} (mol) **(1)** EITHER % of Fe^{2+} remaining at titration = 100 x 2.42775 x 10^{-2} / 2.4829 x 10^{-2} = 97.7785 (%) **(1)** % Oxidized = 100 − 97.7785 = 2.221 (%) **(1)** OR Amount oxidized = 2.4829 x 10^{-2} − 2.42775 x 10^{-2} = 5.516 x 10^{-4} (mol) **(1)** % Oxidized = 5.516 x 10^{-4} x 100 / 2.4829 x 10^{-2} = 2.221 (%) **(1)**		5
	ROUTE 2 (via mass) mass from titration = 2.42775 x 10^{-2} x 277.9 = 6.7467 (g) **(1)** % of Fe^{2+} remaining at titration = 100 x 6.7467 / 6.9 = 97.7785 (%) **(1)** % Oxidized = 100 − 97.7785 = 2.221 (%) **(1)** Ignore SF except 1 SF unless justified in b(iv) Correct answer no working scores 5 marks 90.22% obtained from failure to multiply by 10 scores 4 marks		

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Question Number	Acceptable Answers	Reject	Mark
(b)(iv)	3 (significant figures) because all the data (except A_r(H)) is given to 3 SF OR 2 (significant figures) because the least precise data (A_r(H)) is 2 SF OR 2 (significant figures) because the data is to three figures. After processing only two figures are certain. OR 1 (significant figure) because of the subtraction of two similar numbers.		1

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	Alkali neutralizes the acid shifting the equilibrium to the left OR Alkali neutralizes the acid so E value for half cell becomes less (than +2.20 V) ALLOW 'Reacts with' and 'removes' for 'neutralizes' IGNORE Just "shifts equilibrium to the left"		1

Question Number	Acceptable Answers	Reject	Mark
(c)(ii)	$4Fe^{3+} + 4H_2O \rightarrow 3Fe^{2+} + FeO_4^{2-} + 8H^+$ OR Multiples Species **(1)** balance **(1)** Ignore state symbols even if incorrect		2

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	Required half cell value is $E^{\ominus}$ = (+)0.77 **(1)** $E^{\ominus}_{cell}$ = (0.77 – 2.20 =) −1.43 V ($E^{\ominus}_{cell}$ negative so disproportionation) not feasible **(1)** TE on calculated negative value of $E^{\ominus}_{cell}$ No TE on positive value for $E^{\ominus}_{cell}$ OR Correct application of anti-clockwise rule e.g. $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ $E^{\ominus}$ = +0.77 V $FeO_4^{2-}(aq) + 8H^+(aq) + 3e^- \rightleftharpoons Fe^{3+}(aq) + 4H_2O(l)$ $E^{\ominus}$ =+2.20 V Equations in order of increasing $E^{\ominus}$ value **and** arrows shown **(1)** Anti-clockwise rule shows top reaction moves left and bottom reaction moves right so disproportionation not feasible **(1)**		2

Q66.

Question number	Acceptable Answer	Additional Guidance	Marks
(a)	An answer that makes reference to the following points: • a species that gains electrons **OR** a species that removes (one or more) electrons from another species		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An explanation that makes reference to one of the following pairs: **either** • oxidation number of Cl changes from +5 to +4 (1) • therefore ClO_3^- is the oxidising agent (because Cl (in ClO_3^-) has been reduced) (1) **or** • oxidation number of S changes from +4 to +6 (and oxidation number of H does not change) (1) • (therefore S (in SO_2) has been oxidised) therefore ClO_3^- is the oxidising agent (1)	Allow oxidation number of Cl goes down by 1 Allow oxidation number of S goes up by 2 (and oxidation number of H does not change)	**2**

Question number	Acceptable Answer	Additional Guidance	Marks
(c)(i)	$2ClO_2 + 2OH^- \rightarrow ClO_2^- + ClO_3^- + H_2O$ • species (1) • balanced (1)	Ignore state symbols	**2**

Question number	Acceptable Answer	Additional Guidance	Marks
(c)(ii)	An answer that makes reference to the following point: • because chlorine (in ClO_2) is both oxidised and reduced	Allow chlorine has gone from +4 to +3 and +5 (maybe shown underneath the equation in ci)	**1**

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Q67.

Question Number	Answer	Additional Guidance	Mark
	Method 1 • **(M1)** mass of benzoic acid in 50 cm^3 **(1)** • **(M2)** no. of moles of benzoic acid in 50 cm^3 **(1)** OR Method 2 • **(M1)** moles of benzoic acid in 1000 cm^3 **(1)** • **(M2)** no. of moles of benzoic acid in 50 cm^3 **(1)** then • **(M3)** evaluation of the number of molecules of benzoic acid in 50 cm^3 **(1)**	Example of calculation m=(1.70 x 0.05=)0.0850 (g) n=(0.0850 ÷ 122=) 6.967 ... x 10^{-4} (mol) n=(1.70 ÷ 122 =) 0.01393... (mol) n=(0.01393... x 0.05 =) 6.967 ... x 10^{-4} (mol) N= (6.967 ...x 10^{-4} x 6.02 x 10^{23}=) =4.19 x 10^{20} / 4.2 x 10^{20} Ignore sf except 1sf Penalise excessive (6+) SF Allow use of 6.0 x 10^{23} to give 4.18 x 10^{20} for (3) Correct final answer without working scores (3) TE throughout	**(3)**

Q68.

Question Number	Answer	Additional Guidance	Mark
(i)	• equation	Example of equation $Cl_2 + 2KBr \rightarrow Br_2 + 2KCl$ Accept ionic equation $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ Allow multiples Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • **(M1)** the precipitate is a mixture of silver chloride and silver bromide **or** not all of the bromide ions were oxidised **(1)** • **(M2)** silver chloride/AgCl dissolves in dilute ammonia **(1)** • **(M3)** silver bromide/AgBr does not dissolve in dilute ammonia **(1)**	Allow Some bromide ions are still present/bromide ions were in excess/both chloride and bromide ions are present Do not award references to Cl^- dissolving Silver bromide only dissolves in concentrated ammonia	**(3)**

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following point: • iodine is a weaker oxidising agent than chlorine **or** iodine cannot oxidise bromide ions **or** iodine is a stronger reducing agent	Accept reverse arguments Ignore Just references to reactivity/displacement e.g. iodine is less reactive/cannot displace	**(1)**

Q69.

Question Number	Answer	Mark
(i)	**The only correct answer is D** ***A*** *is not correct because the measurement uncertainty is doubled as there are two burette readings* ***B*** *is not correct because this gives the largest measurement uncertainty* ***C*** *is not correct because the measurement uncertainty is doubled as the pipette is used twice*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	calculation of Q **(1)** calculation of enthalpy change **(1)** answer to nearest whole number **and** with negative sign **(1)**	Example of calculation Q=(100 x 4.18 x 6.5=) = 2717 (J) / 2.717 kJ ΔH= 2.717 ÷ 0.05= (–)54.340 = –54 (kJ mol^{-1}) Allow TE at each stage Correct answer with no working scores (3)	**(3)**

Q70.

Question Number	Answer	Additional guidance	Mark
(i)	• evaluation of number of moles of 2-hydroxybenzoic acid used (1) • calculation of mass of aspirin at 100% yield (1) • calculation of mass of aspirin at 65% yield (1)	Example of calculation 2 / 138 = 0.0145 mol 0.0145 x 180 = 2.61 g 2.61/100 x 65 = 1.70 g Correct answer with no working scores 3 marks	**3**
(ii)	The mark for each reason must be linked with the correct improvement. • Improvement: swap the water inflow and outflow in the condenser (1) • Reason: to improve efficiency of condensing process (1) • Improvement: add anti-bumping granules to flask (1) • Reason: to promote smooth boiling/to prevent material escaping from top of condenser (1) • Improvement: insert condenser into neck of flask (1) • Reason: to prevent escape of reagents (1)		**6**

Q71.

Question Number	Answer	Additional Guidance	Mark
	• calculate amount paracetamol (1) • calculate mass of phenol if 100% yield (1) • calculate mass of phenol taking into account overall yield (1) OR • Target mass of paracetamol, accounting for % yield (1) • Target moles of paracetamol, accounting for % yield (1) • calculate mass of phenol taking into account overall yield (1)	<u>Example of calculation</u> 1000 ÷ 151 = 6.6225 (mol) 6.6225 × 94.0 = 622.52 (g) 622.52 × (100 ÷ 19.04) = 3269.5 g = 3.27 kg 1000 x 100 ÷19.04 = 5252.1 (g) 5252.1 ÷ 151 = 34.782 (mol) 34.782 x 94 = 3269.5 (g) = 3.27 kg NOTE overall % yield is 0.32 x 0.85 x 0.7 = 19.04 % Allow full marks for final answer calculated from intermediate values rounded to 2 or more SF e.g. 3.28 from 19.0 and 622.5 Allow TE throughout Ignore SF except 1 SF Correct answer with no working scores (3)	(3)

Q72.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(i)	• 203.3 (g mol^{-1})	Allow 203 if Mg = 24	**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following point:		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)(iii)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ equation and state symbols		**1**

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	An answer that makes reference to the following points: • AgCl dissolves in dilute aqueous ammonia (and in concentrated aqueous ammonia (1) • AgBr is insoluble / only partially soluble in dilute aqueous ammonia, but is soluble in concentrated aqueous ammonia (1) • AgI is insoluble in both dilute and concentrated aqueous ammonia (1)		**3**

Q73.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to: • (similarity) both are basic because they have a lone pair of electrons on the nitrogen atom which accepts a proton **(1)** • (difference 1)in $C_6H_5NH_2$ the lone pair of electrons of the nitrogen atom becomes incorporated with the delocalised ring of electrons and so is less able to accept a proton hence a weaker base **(1)** • (difference 2) the alkyl group/ C_4H_9 is electron-releasing / positively inductive and means the lone pair of electrons of the nitrogen atom are more able to accept a proton hence a stronger base **(1)**	Diagrams can be used to score Comparison of basicity/nitrogen's lone pair of electrons/proton acceptance only need to be mentioned once.	**(3)**

Q74.

Question Number	Answer	Additional Guidance	Mark
	• (**M1**) calculation of number of moles of NaOH weighed out **(1)** • (**M2**) concentration of NaOH solution **(1)** • (**M3**) number of moles of NaOH in titre **(1)** • (**M4**) molar concentration of CH_3COOH solution **(1)** • (**M5**) concentration in g dm^{-3} of CH_3COOH solution to 2/3SF **(1)**	<u>Example of calculation</u> n(NaOH)= 3.80 ÷ 40 = 0.095/ 9.5 x 10^{-2} (mol) [NaOH]= 0.095÷0.250=0.38(mol dm^{-3}) n(NaOH) = 0.38 x 0.0119 = 0.004522/ 4.522 x 10^{-3} (mol) [CH_3COOH] = 4.522 x 10^{-3} ÷ 0.025 = 0.18088 (mol dm^{-3}) [CH_3COOH] = 0.18088 x 60 = 10.8528 (g dm^{-3}) = 10.9 / 11 (g dm^{-3}) Do not award 10.90 (g dm^{-3}) Correct answer without working scores (5) Accept steps in a different order, e.g. moles x 60 before dividing by 0.025 TE throughout Penalise incorrect units in M5 only	**(5)**

Q75.

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)

Q76.

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)

Q77.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>(i)</td><td>• completed table</td><td>Exemplar table
<table>
<tr><td>Titration number</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>Final burette reading / cm³</td><td>13.00</td><td>25.50</td><td>37.90</td><td>50.00</td></tr>
<tr><td>Initial burette reading / cm³</td><td>0.25</td><td>13.00</td><td>25.50</td><td>37.90</td></tr>
<tr><td>Titre / cm³</td><td>12.75</td><td>12.50</td><td>12.40</td><td>12.10</td></tr>
<tr><td>Concordant titres (✓)</td><td></td><td>✓</td><td>✓</td><td></td></tr>
</table>
COMMENT
Allow 12.5/ 12.4 /12.1
Do not award additional ticks</td><td>(1)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>(ii)</td><td>• calculation of percentage measurement uncertainty</td><td>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%</td><td>(1)</td></tr>
</table>

Q78.

Question Number	Answer	Additional guidance	Mark
(i)	• brown fumes (1) • a green/blue solution forming (1)		2
(ii)	• $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$	State symbols must be present	1
(iii)	• amount of thiosulfate (1) • uses amount of thiosulfate = amount of iodine to determine amount of thiosulfate = amount of copper(II) ions in 25 cm^3 portion (1) • evaluation of number of moles of Cu in sample (1) • calculates mass of Cu (1) • percentage copper to **3.s.f** (1)	Example of calculation amount of thiosulfate = $\frac{22.7 \times 0.25}{1000}$ = 5.675×10^{-3} (mol) 5.675×10^{-3} (mol) = amount of copper(II) ions in 25 cm^3 portion amount of Cu in sample = $5.675 \times 10^{-3} \times 10$ = 5.675×10^{-2} (mol) mass of Cu = $5.675 \times 10^{-2} \times 63.5$ = 3.603625 percentage copper = 3.603625 x 100 /5.00 = 72.0725 = 72.1% Allow ecf from 2nd mark Correct answer to 3.s.f with no working scores 5 marks	5
(iv)	• calculation of percentage uncertainty from balance = ±0.005x 2 x100/5.00 = 0.2% and percentage uncertainty in mean titre from burette = 2x±0.05 x 100 /22.7 = 0.44% (1) • so burette reading is most significant (1)		2

Q79.

Question Number	Answer	Additional guidance	Mark
(i)	• calculation of moles of $VCl_2(aq)$ **(1)** • calculation of moles of $Cl_2(g)$ **(1)** • deduction of whole number ratio of V^{2+} : Cl_2 **(1)** • deduction of electrons lost per vanadium ion **(1)** • deduction of final oxidation number of V **(1)**	Example of calculation $(40/1000) \times 0.100 = 4 \times 10^{-3} / 0.004$ (mol) $(144/24000) = 6 \times 10^{-3} / 0.006$ (mol) $2V^{2+} : 3Cl_2$ allow $V^{2+} : 1.5Cl_2$ 6 electrons lost by $2V^{2+}$, so 3 lost per V^{2+}, (+)5 Allow TE throughout Correct answer with no working scores M5 only	**(5)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• purple / lilac / violet **(1)** • to yellow (solution) **(1)**	Ignore references to blue / green / turquoise or similar, as intermediate colours, regardless of order If no final oxidation state given in (d)(i) do not award M2 Allow lavender / mauve for M1 Mark consequentially from (d)(i) Do not award colourless Use list principle for additional inappropriate intermediate colours e.g. red / pink For consequential marking from (d)(i) V(IV) – blue ; V(III) – green If both colours are given but the wrong way round, allow 1 mark out of 2	**(2)**

Q80.

Question Number	Answer	Mark
	The only correct answer is D (3.6×10^{23}) ***A** is not correct because the number of moles of $(NH_4)_2SO_4$ has been divided by 3, rather than multiplied by 3* ***B** is not correct because it is the number of SO_4^{2-} ions* ***C** is not correct because it is the number of NH_4^+ ions*	**(1)**

Q81.

Question Number	Answer	Additional Guidance	Mark
(i)	• conversion of pressure, volume and temperature to correct units **(1)** • rearrangement of ideal gas equation so n=PV ÷ RT and calculation of n **(1)** • conversion of answer into mass to 2/3 SF **(1)**	Example of calculation: 207kPa = 207 000 Pa 8.98 dm^3 = 0.00898 m^3, 20°C = 293 K $n = \frac{207\,000 \times 0.00898}{8.31 \times 293} = 0.7634...$ = 0.7634.... x 28 = 21.37647.. = 21.4 / 21 (g) Correct answer with no working scores 3 TE on both parts of the calculation	**(3)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• The temperature increase will result in an increase in pressure because p is (directly) proportional to T (at constant volume and moles of gas)	Allow $p \propto T$ Reference to p=nRT/V	**(1)**

Q82.

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)**

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)**

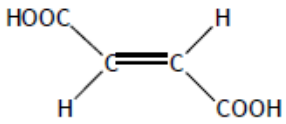
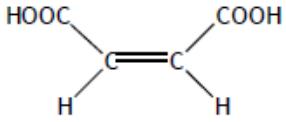
Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) **(1)** M2 because the (number of) moles of sodium hydroxide is unaffected **(1)**	 M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow 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 x 100% = (±)0.980392156% 10.20 (±)0.30 x 100% = (±)0.12% 250.0 **and** (±)0.040 x 100% = (±)0.4% 10.0 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)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	<table><tr><th>Structure</th><th>Test with Br_2 water</th><th>Test with acidified $K_2Cr_2O_7$</th></tr><tr><td>HOOCCH=CHCOOH</td><td>✓</td><td>x</td></tr><tr><td>$HOCH_2CH=CHCH_2COOH$</td><td>✓</td><td>✓</td></tr><tr><td>$CH_3CH_2CH_2CH_2CH_2COOH$</td><td>x</td><td>x</td></tr></table> Left hand column correct **(1)** Right hand column correct **(1)**	3 correct ticks with no crosses scores 1 Ignore descriptions of result in terms of colour (changes) / reactions occurring	**(2)**

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)**

Q83.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• correct equation	<u>Examples of equation</u> $Na_2B_4O_7.10H_2O + 2HCl \rightarrow 4H_3BO_3 + 2NaCl + 5H_2O$ **or** $Na_2B_4O_7.10H_2O + 2HCl \rightarrow 4B(OH)_3 + 2NaCl + 5H_2O$ Allow multiples Allow reversible arrow provided the equation is written in the direction shown. Ignore state symbols, even if incorrect	**(1)**