



# Mark Scheme (Results)

October 2023

Pearson Edexcel International Advanced  
Subsidiary Level In Chemistry (WCH12)  
Paper 01 Unit 2: Energetics, Group Chemistry,  
Halogenoalkanes and Alcohols

## Section A

Question Number	Answer	Mark
1	<p>The only correct answer is C (<math>\text{CF}_4(\text{g}) \rightarrow \text{C}(\text{g}) + 4\text{F}(\text{g})</math>)</p> <p><i>A is incorrect because this equation represents the bond formation of 4 CF bonds and is exothermic</i></p> <p><i>B is incorrect because this equation represents the enthalpy change of formation of <math>\text{CF}_4</math> from its elements</i></p> <p><i>D is incorrect because this equation represents the enthalpy change of the reaction of <math>\text{CF}_4</math> to its elements</i></p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
2	<p>The only correct answer is A (<math>-554 - 394 + 1216</math>)</p> <p><i>B is incorrect because the sign of the enthalpy change of formation of the reactant is incorrect</i></p> <p><i>C is incorrect because the sign of the enthalpy change of formation of the products is incorrect</i></p>	<p>(1)</p> <p>Computer</p>

	<i>D is incorrect because sign of the enthalpy change of formation of both the reactant and products is incorrect</i>	
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Question Number	Answer	Mark
3	<p>The only correct answer is D (C<sub>9</sub>H<sub>20</sub>)</p> <p><i>A is incorrect because the increment is ~630 kJ mol<sup>-1</sup> so expected enthalpy change of combustion would be -4139 kJ mol<sup>-1</sup></i></p> <p><i>B is incorrect because the increment is ~630 kJ mol<sup>-1</sup> so expected enthalpy change of combustion would be -4769 kJ mol<sup>-1</sup></i></p> <p><i>C is incorrect because the increment is ~630 kJ mol<sup>-1</sup> so expected enthalpy change of combustion would be -5399 kJ mol<sup>-1</sup></i></p>	<p>(1)</p> <p>Computer</p>
Question Number	Answer	Mark
4	<p>The only correct answer is D (H<sub>2</sub>S, ✓, ✓, X)</p> <p><i>A is incorrect because boron trifluoride is not polar, <del>does not contain hydrogen</del> and has London forces</i></p>	<p>(1)</p> <p>Computer</p>

	<p><b>B</b> is incorrect because methane does not hydrogen bond</p> <p><b>C</b> is incorrect because ammonia is polar and has hydrogen bonds</p>	
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Question Number	Answer	Mark
5	<p>The only correct answer is A (butan-1-ol)</p> <p><b>B</b> is incorrect because the hydrocarbon section of the molecule is branched</p> <p><b>C</b> is incorrect because the hydrocarbon section of the molecule is branched</p> <p><b>D</b> is incorrect because pentane does not hydrogen bond</p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
6	<p>The only correct answer is C (4)</p> <p><b>A</b> is incorrect because neither the oxygen atoms nor the hydrogen atoms balance</p> <p><b>B</b> is incorrect because neither the oxygen atoms nor the hydrogen atoms balance</p>	<p>(1)</p> <p>Computer</p>

	<i>D is incorrect because neither the oxygen atoms nor the hydrogen atoms balance</i>	
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Question Number	Answer	Mark
7	<p><b>The only correct answer is D</b> (<math>\text{S}_2\text{O}_3^{2-} + 2\text{H}^+ \rightarrow \text{SO}_2 + \text{S} + \text{H}_2\text{O}</math>)</p> <p><i>A is incorrect because copper is oxidised and nitrogen is reduced</i></p> <p><i>B is incorrect because iodine is oxidised and some of the oxygen in ozone is reduced</i></p> <p><i>C is incorrect because the reverse reaction is a disproportionation</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>

Question Number	Answer	Mark
8	<p><b>The only correct answer is C</b> (bromine, hydrogen bromide and sulfur dioxide only)</p> <p><i>A is incorrect because hydrogen bromide is oxidised by concentrated sulfuric acid</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>

	<p><i>B is incorrect because the bromide ions reduce the sulfuric acid to sulfur dioxide</i></p> <p><i>D is incorrect because the bromide ions are not strong enough reducing agents to further reduce the sulfuric acid</i></p>	
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Question Number	Answer	Mark
9	<p>The only correct answer is C (solubility of the sulfates)</p> <p><i>A is incorrect because the atomic radius increases</i></p> <p><i>B is incorrect because the reactivity of the elements increases</i></p> <p><i>D is incorrect because the thermal stability of the nitrates increases</i></p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
10	<p>The only correct answer is A (0.33)</p> <p><i>B is incorrect because the increase in volume due to added alkali has been ignored</i></p>	<p>(1)</p> <p>Computer</p>

	<p><i>C is incorrect because the moles of reactant have been added together</i></p> <p><i>D is incorrect because the increase in volume due to the added acid has been ignored</i></p>	
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Question Number	Answer	Mark
11(a)	<p><b>The only correct answer is D</b> (rate decreases and yield increases)</p> <p><i>A is incorrect because a decrease in temperature would decrease the rate but increase the yield</i></p> <p><i>B is incorrect because a decrease in temperature would decrease the rate</i></p> <p><i>C is incorrect because a decrease in temperature would increase the yield</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>
Question Number	Answer	Mark
11(b)	<p><b>The only correct answer is B</b> (rate increases and yield increases)</p> <p><i>A is incorrect because an increase in pressure would increase the yield</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>

	<p><i>C is incorrect because an increase in pressure would increase the rate and increase the yield</i></p> <p><i>D is incorrect because an increase in pressure would increase the rate</i></p>	
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Question Number	Answer	Mark
12	<p><b>The only correct answer is C</b> (the mixture becomes more yellow)</p> <p><i>A is incorrect because the position of equilibrium would change</i></p> <p><i>B is incorrect because coloured ions would still be present</i></p> <p><i>D is incorrect because the removal of the hydrogen ions would move the position of equilibrium to the left</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>



Question Number	Answer	Mark
13(a)	<p>The only correct answer is <b>A</b> (1-methylcyclopentanol)</p> <p><i>B is incorrect because 2-methylcyclopentanol is a secondary alcohol</i></p> <p><i>C is incorrect because 2-methylbutan-1-ol is a primary alcohol</i></p> <p><i>D is incorrect because 3-methylpentan-2-ol is a secondary alcohol</i></p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
13(b)	<p>The only correct answer is <b>C</b> (phosphorus(V) chloride)</p> <p><i>A is incorrect because acidified aqueous potassium dichromate(VI) does not oxidise tertiary alcohols</i></p> <p><i>B is incorrect because bromine water does not react with alcohols</i></p> <p><i>D is incorrect because sodium carbonate solution does not react with alcohols</i></p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
14(a)	<p>The only correct answer is D (<math>\text{C}=\text{O}</math> stretching at <math>1720 - 1700 \text{ cm}^{-1}</math>)</p> <p><i>A is incorrect because the alcohol will have been oxidised</i></p> <p><i>B is incorrect because an aldehyde is not an oxidation product of a secondary alcohol</i></p> <p><i>C is incorrect because the ketone cannot be further oxidised by acidified potassium dichromate(VI)</i></p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
14(b)	<p>The only correct answer is B (<math>\text{C}=\text{O}</math> stretching at <math>1740 - 1720 \text{ cm}^{-1}</math>)</p> <p><i>A is incorrect because the aldehyde product will distil at a lower temperature than the reactant</i></p> <p><i>C is incorrect because the aldehyde is removed from the oxidising agent so cannot be further oxidised</i></p> <p><i>D is incorrect because a ketone is not formed when a primary alcohol is oxidised</i></p>	<p>(1)</p> <p>Computer</p>

Question Number	Answer	Mark
15	<p><b>The only correct answer is B</b> (the C-Cl bond is stronger than the C-Br bond)</p> <p><i>A is incorrect because the solubility of the halogenoalkane does not affect the rate</i></p> <p><i>C is incorrect because the polarity of the C-halogen bond does not affect the rate</i></p> <p><i>D is incorrect because the solubility of the silver salt does not affect the rate</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>

Question Number	Answer	Mark
16	<p><b>The only correct answer is C</b> (2.26)</p> <p><i>A is incorrect because this is half the mass of the product</i></p> <p><i>B is incorrect because only one OH group is replaced by chlorine</i></p> <p><i>C is incorrect because this is double the mass of the product</i></p>	<p><b>(1)</b></p> <p><b>Computer</b></p>

Question Number	Answer	Mark
17	<p>The only correct answer is B (2-chloropropane)</p> <p><i>A is incorrect because a primary amine would be formed</i></p> <p><i>C is incorrect because alkanes do not react with ammonia</i></p> <p><i>D is incorrect because alkenes do not react with ammonia</i></p>	<p>(1)</p> <p>Computer</p>

**TOTAL FOR SECTION A = 20 MARKS**

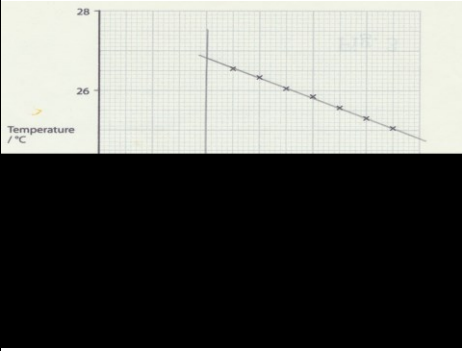
<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>4</b>	<b>5</b>	<b>5</b>	<b>6</b>

## Section B

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	An answer that makes reference to the following point:		(1)
	1. balanced ionic equation	$\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$  Accept $\text{H}_3\text{O}^+ + \text{OH}^- \rightarrow 2\text{H}_2\text{O}$  Accept multiples  Ignore full equation as working  Ignore state symbols even if incorrect  Do not award uncanceled spectator ions	Graduate

Question Number	Answer	Additional Guidance	Mark
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<b>18(a)(ii)</b>	<p>An answer that makes reference to the following points:</p> <ol style="list-style-type: none"> <li>1. heat energy released under standard conditions</li> <li>2. (when) 1 mol of <b>water</b> is produced (by the reaction of acid (1) with alkali)</li> </ol>	<p><b>(1)</b> Allow enthalpy change under standard conditions</p> <p>Allow for standard conditions 1 atm / 1(.01) x10<sup>5</sup>Pa and a stated temperature / 298K / 25°C</p> <p>Ignore standard states</p> <p>Do not award energy required</p>	<p><b>(2)</b></p> <p><b>Expert</b></p>
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Question Number	Answer	Additional Guidance	Mark
18(b)(i)	<p>An answer that makes reference to the following points:</p> <p>3. two lines of best fit drawn</p> <p>4. value <math>\pm 0.2</math></p>	<p>(1) Cooling may be shown as straight line or smooth curve</p> <p><math>\Delta T = 26.8 - 22.4 = 4.4^{\circ}\text{C}</math></p> <p>(1) Accept value between <math>4.2^{\circ}\text{C}</math> and <math>4.6^{\circ}\text{C}</math> from a correct vertical extrapolation at 120s</p> <p>Example of extrapolation</p> 	<p>(2)</p> <p><b>Expert</b></p>

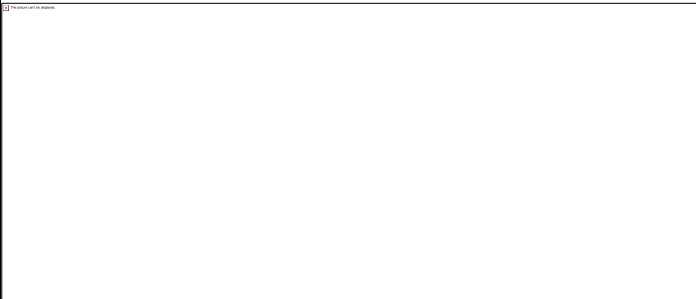
Question Number	Answer	Additional Guidance	Mark
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<b>18(b)(ii)</b>	An answer that makes reference to the following points:	<u>Example of calculation:</u>	<b>(3)</b>
	5. energy transferred to solutions <b>(1)</b>	$0.05 \times 4.2 \times 4.4 = 0.924 \text{ (kJ)}$ $50 \times 4.2 \times 4.4 = 924 \text{ (J)}$	<b>Expert</b>
	6. moles of water formed <b>(1)</b>	$(25 \div 1000) \times 0.8 = 0.02 \text{ (mol)}$	
	7. enthalpy change of neutralisation with negative sign and units <b>(1)</b>	$0.924 \div 0.02 = -46.2 \text{ kJ mol}^{-1} / -46,200 \text{ J mol}^{-1}$ TE on b(i) and throughout b(ii) Ignore SF except 1 SF	

Question Number	Answer	Additional Guidance	Mark
<b>18(b)(iii)</b>	An explanation that makes reference to the following points:		<b>(2)</b>
	1. (because the calculation has not taken into account the) energy required to heat the calorimeter/ the (total) heat capacity would be greater <b>(1)</b>  2. the value(of the enthalpy change of neutralisation) would be more exothermic/more negative <b>(1)</b>	Ignore references to the relative heat capacity of copper/water(solution)  Allow higher/ increase/ greater	<b>Expert</b>



Question Number	Answer	Additional Guidance	Mark
18(c)(i)	<p>An answer that makes reference to the following points:</p> <p>nucleophilic <b>and</b> substitution(reaction)</p>	<p>Allow nucleophile substitution</p>	<p><b>(1)</b></p> <p><b>Clerical</b></p>

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	<p>An answer that makes reference to the following points:</p> <p>3. dipole on C-Br bond</p> <p>4. lone pair on O of OH<sup>-</sup></p> <p>5. curly arrow from lone pair to <b>C of C-Br</b>. If no lone pair shown, allow curly arrow from O</p> <p>6. arrow from C-Br to Br or just beyond</p> <p>7. organic product</p> <p>8. Br<sup>-</sup></p>	<p><u>Example of mechanism</u></p>  <p>Allow product as structural formula</p> <p>Allow NaBr</p> <p>Ignore Na<sup>+</sup></p> <p>Do not award HBr</p> <p>6 points correct scores (3)</p> <p>4 /5 points correct scores (2)</p>	<p><b>(3)</b></p> <p><b>Expert</b></p>

		2 / 3 points correct scores (1) Ignore intermediate/ transition state if shown	
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Question Number	Answer	Additional Guidance	Mark
<b>18(c)(iii)</b>	An answer that makes reference to the following points:		<b>(2)</b>
	1. elimination	<b>(1)</b> Do not award addition/substitution/dehydration/acid/base	<b>Graduate</b>
	2. ethanol / alcohol	<b>(1)</b> Allow ethanolic /alcoholic solution	

(Total for Question 18 = 16 marks)

Question Number	Answer	Additional Guidance	Mark
<b>19(a)(i)</b>	An answer that makes reference to the following point:		<b>(1)</b>

	yellow (precipitate/solid)	Allow pale yellow	<b>Clerical</b>
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Question Number	Answer	Additional Guidance	Mark
<b>19(a)(ii)</b>		<u>Example of calculation</u>	<b>(3)</b>
	3. moles of silver iodide <b>(1)</b>	$0.162 \div (107.9 + 126.9) = 6.8995 \times 10^{-4} / 0.00068995 \text{ (mol)}$	<b>Expert</b>
	4. mass of potassium iodide in mixture <b>(1)</b>	$6.8995 \times 10^{-4} \times (39.1 + 126.9) = 0.11453 \text{ (g)}$	
	5. % of potassium iodide in mixture <b>(1)</b>	$(0.11453 \div 2.49) \times 100 = 4.5997$ $= 4.6 / 4.60 \text{ (\%)}$ Answer to 2 or 3 SF Allow TE on transcription errors unless final answer is >100% Do not award 4.5% for M3	

Question Number	Answer	Additional Guidance	Mark
<b>19(b)</b>	An answer that makes reference to the following points:	Oxidation numbers may be shown on equation	<b>(2)</b>

	1. manganese <b>reduced</b> from (+) 4 to (+) 2 <b>(1)</b>		<b>Expert</b>
	2. chlorine is <b>oxidised</b> from -1 to 0 <b>(1)</b>	Allow chloride for chlorine If no other mark awarded: Allow 1 mark for manganese reduced and chlorine oxidised OR all four correct oxidation states of Mn and Cl	

Question Number	Answer	Additional Guidance	Mark
<b>19(c)</b>	An answer that makes reference to the following points:		<b>(2)</b>
	3. aqueous layer is yellow <b>(1)</b> 4. hexane layer is purple/pink/violet <b>(1)</b>	Allow orange / brown /straw / colourless Do not award red/red-brown/yellow-green Allow lilac If colours are reversed allow one mark.	<b>Graduate</b>

Question	Answer	Additional Guidance	Mark
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Number																	
*19(d)	<p>This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table><tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></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> <p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table><tr><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></tr></table>	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		Number of marks awarded for structure of answer and sustained lines of reasoning	<p>Guidance on how the mark scheme should be applied.</p> <p>The mark for indicative content should be added to the mark for lines of reasoning. For example, a response 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).</p> <p>If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</p> <p>In general it would be expected that</p> <p>5 or 6 indicative points would get 2 reasoning marks</p> <p>3 or 4 indicative points would get 1 reasoning mark</p> <p>0, 1 or 2 indicative points would get zero reasoning marks</p>	<p>(6)</p> <p>Expert</p>
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																
	Number of marks awarded for structure of answer and sustained lines of reasoning																

Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).	
Answer is partially structured with some linkages and lines of reasoning	1		
Answer has no linkages between points and is unstructured	0		
<p><b>Indicative content</b></p> <p><b>IP1 iodine has (only) London forces/cannot form hydrogen bonds</b></p> <p><b>IP2 water molecules form hydrogen bonds (and London forces and permanent dipoles)</b></p> <p><b>IP3 hydrogen bonds are stronger than London forces/ the strongest (intermolecular force)</b></p> <p><b>IP4 hexane forms (only) London forces/cannot form hydrogen bonds</b></p> <p><b>IP5 London forces formed between iodine and hexane are similar (in strength) to those (broken) in hexane/ iodine (so iodine dissolves)</b></p>		<p><b>Comment:</b> Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning</p> <p>Accept instantaneous/induced dipole/ IDID/dispersion/ van der Waals' forces for London forces</p> <p>Allow London forces between iodine and hexane are greater than those between hexane</p>	

	<p><b>IP6 Iodine cannot form hydrogen bonds/ only forms weak London forces with water so the (hydrogen) bonds between water molecules cannot be broken (so iodine does not dissolve in water)</b></p>	<p>Any reference to both hexane and iodine having permanent dipole interactions penalise in 1 IP only.</p> <p>Any statement that hexane has more/stronger London forces than iodine is incorrect so loses 1 reasoning mark.</p>	
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**(Total for Question 19 = 15 marks)**

<b>Question Number</b>	<b>Answer</b>	<b>Additional Guidance</b>	<b>Mark</b>
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<b>20(a)(i)</b>	An answer that makes reference to the following points:		<b>(2)</b>
	5. equation <b>(1)</b>  6. state symbols <b>(1)</b>	$\text{CO}_3^{2-}(\text{s/aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ $\text{CO}_3^{2-}(\text{s/aq}) + 2\text{H}_3\text{O}^+(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$ M2 depends on M1 or near miss e.g. full equation or uncanceled spectator ions	<b>Graduate</b>

Question Number	Answer	Additional Guidance	Mark
<b>20(a)(ii)</b>	7. the mixture/solution would go cloudy/milky/ a white precipitate would form <b>(1)</b>	Ignore $\text{CaCO}_3$ formed Do not award effervescence/fizzing/misty	<b>(1)</b>  <b>Graduate</b>

Question Number	Answer	Additional Guidance	Mark
<b>20(b)(i)</b>		<u>Example of calculation:</u>	<b>(4)</b>
	8. calculate mols hydrochloric acid in titre <b>(1)</b>  9. calculate mols calcium hydroxide in $25.0 \text{ cm}^3$ <b>(1)</b>	$18.95 \times 0.0500 \times 10^{-3} = 9.475 \times 10^{-4} \text{ (mols)}$  $9.475 \times 10^{-4} \div 2 = 4.7375 \times 10^{-4} \text{ (mols)}$	<b>Expert</b>

10.	calculate mass calcium hydroxide in 25.0 cm <sup>3</sup>	(1)	$4.7375 \times 10^{-4} \times (40.1+34) = 3.51049 \times 10^{-2} \text{ (g)}$	
11.	calculate mass calcium hydroxide in 1.00 dm <sup>3</sup>	(1)	$3.51049 \times 10^{-2} \times 1000 \div 25 = 1.4042 \text{ (g dm}^{-3}\text{)}$ Ignore SF except 1 SF Alternative method for M3/M4 $4.7375 \times 10^{-4} \times 1000 \div 25 = 0.01895/ 1.895 \times 10^{-2}$	
12.	moles calcium hydroxide in 1 dm <sup>3</sup>	(1)	$1.895 \times 10^{-2} \times (40.1+34) = 1.4042 \text{ (g dm}^{-3}\text{)}$	
13.	mass calcium hydroxide in 1 dm <sup>3</sup>	(1)	If 25/18.95 swapped answer of 2.44 scores 2	

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	An answer that makes reference to the following points:		(2)
14.	strontium hydroxide is more soluble than calcium hydroxide (1)	Accept because solubility of the hydroxides increases down the group	Expert
15.	(so) titre value would be greater(than that for calcium) or reverse (1)	M2 must be consistent with M1.	

		ALLOW one mark for strontium hydroxide is less soluble so titre value would be smaller	
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Question Number	Answer	Additional Guidance	Mark
20(c)	<p>An explanation that makes reference to three of the following points</p> <p>16. the concentration of carbonic acid /H<sub>2</sub>CO<sub>3</sub> will increase (1)</p> <p>17. the equilibrium position will move to the RHS (1)</p> <p>18. (the hydrogen ion concentration will increase so) the acidity will increase (1)</p>	Do not award M3 if M2 is incorrect.	<p>(3)</p> <p>Expert</p>

(Total for Question 20 = 12 marks)

**TOTAL FOR SECTION B = 42 MARKS**

### Section C

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	An answer that makes reference to the following points:	<u>Example of calculation:</u>	(3)
19.	calculate mass oxygen in compound X (1)	$1.92 - (1.08 + 0.131) = 0.709 \text{ (g)}$	Expert
20.	calculate moles carbon,hydrogen and oxygen (1)	$1.08 \div 12 = 0.0900 \text{ (mols) carbon}$ $0.131 \text{ (mols) hydrogen}$ $0.709 \div 16 = 0.044313 \text{ (mols) oxygen}$	
21.	mole ratio <b>and</b> empirical formula (1)	$0.09 : 0.131 : 0.043688$ $2.03 ; 2.96 : 1$ $\text{C}_2\text{H}_3\text{O}$ TE from incorrect masses but rounding must be appropriate	

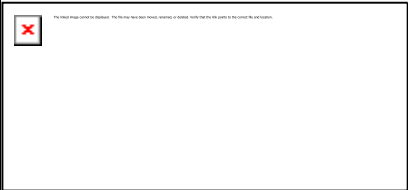

		If only two elements considered award M3 if correct ( $C_2H_3$ )	
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Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	An answer that makes reference to the following points:		(2)
	22. $C_4H_6O_2$ (1)		Expert
	23. empirical formula mass x 2 = mass of molecular ion (1)	Evidence of $M_r = 86$ scores M2	

Question Number	Answer	Additional Guidance	Mark
21(a)(iii)	An answer that makes reference to the following points:		(2)
	24. $C=C$ /alkene/carbon-carbon double bond (1)		Graduate

	25.    -COOH/carboxylic acid/carboxyl	(1)	Do not award carbonyl	
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Question Number	Answer		Additional Guidance	Mark
21(a)(iv)	An answer that makes reference to the following points:			(2)
	26.    peak at 41    C <sub>3</sub> H <sub>5</sub> <sup>+</sup>	(1)	Allow any acceptable structure with C <sub>3</sub> H <sub>5</sub> <sup>+</sup>	Graduate
	27.    peak at 45    COOH <sup>+</sup>	(1)	Allow CO <sub>2</sub> H <sup>+</sup> Do not award CHO <sub>2</sub> <sup>+</sup> Positive charge can be anywhere on ion Penalise omission of positive charge and/or presence of negative charge once only	

Question Number	Answer		Additional Guidance	Mark
21(a)(v)	An answer that makes reference to the following point:			(1)
			Accept	Expert
				

		The arrangement around the double bond must be displayed. Accept skeletal formula	
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Question Number	Answer	Additional Guidance	Mark
21(b)(i)	An explanation that makes reference to the following points:		(3)
	28. provides an alternative pathway/route with a lower activation energy	(1) Allow $E_a^{\text{cat}}$ at a lower energy shown on diagram	Expert
	29. so a greater proportion of molecules have $E > E_a$ /area under the curve to the right of $E_a$ increases	(1) M2 can be shown on diagram	
	30. so a higher proportion of collisions are successful	(1) Allow higher frequency of successful collisions	

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	An answer that makes reference to the following point:		(1)
	1. $\text{CH}_2=\text{CH}-\text{CHO} + [\text{O}] \rightarrow \text{CH}_2=\text{CHCOOH}$	Accept correct displayed/skeletal/structural formulae provided aldehyde and carboxyl groups are clear.	Graduate

		Do not award molecular formulae/-COH in propenal -CHO <sub>2</sub> in carboxylic acid	
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Question Number	Answer	Additional Guidance	Mark
21(c)(i)	<p>An answer that makes reference to the following points:</p> <p>2. potassium manganate(VII)/ potassium permanganate/KMnO<sub>4</sub> (1)</p> <p>3. acidified/cold/room temperature/dilute aqueous solution (1)</p>	<p>M2 depends on M1 or near miss Do not award heat(under reflux)</p>	<p>(2)</p> <p><b>Graduate</b></p>

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	<p>An explanation that makes reference to two of the following points:</p> <p>4. from propene the starting material is crude oil which is non-renewable/finite (1)</p> <p>5. from propane-1,2,3-triol, the starting material is from biomass/uses a by-product/reduces waste from biodiesel production</p> <p>6. propane-1,2,3-triol route produces only water as unwanted product (1)</p>	<p>Allow glycerol for propane-1,2,3-triol</p> <p>Ignore references to greenhouse gases or global warming</p> <p>Ignore references to fermentation</p>	<p>(2)</p> <p><b>Expert</b></p>



	7. from propene, manganese compounds need to be separated		
		(1)	
		(1)	

**(Total for Question 21 = 18 marks)**

**TOTAL FOR SECTION C = 18 MARKS**

**TOTAL FOR PAPER = 80 MARKS**