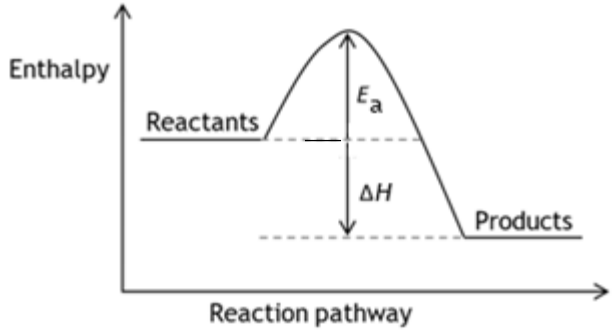
Mark Scheme (Results)

Summer 2021

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

Section A

Question Number	Answer	Mark
1	 **The only correct answer is A** ( ) ***B*** *is incorrect because the labels are incorrect* ***C*** *is incorrect because the labels are incorrect and this is for an endothermic reaction* ***D*** *is incorrect because the labels are incorrect and is for an endothermic reaction*	**1**

Question Number	Answer	Mark
2	**The only correct answer is D** ($\Delta_r H$) ***A*** *is incorrect because this is not an enthalpy of atomisation* ***B*** *is incorrect because carbon monoxide is not the final combustion product of carbon* ***C*** *is incorrect because two moles of carbon monoxide are formed*	**1**

Question Number	Answer	Mark
3	**The only correct answer is A** (0.01) ***B*** *is incorrect because this is the average rate of reaction over 15 seconds* ***C*** *is incorrect because this is the average rate of reaction up to 8 seconds* ***D*** *is incorrect because this is the concentration reading at 8 seconds*	**1**

Question Number	Answer	Mark
4	**The only correct answer is C** (Y and W) ***A*** *is incorrect because the curve is for a lower temperature* ***B*** *is incorrect because the curve is for a lower temperature and the* E_a *has increased* ***D*** *is incorrect because the* E_a *has increased*	**1**

Question Number	Answer	Mark
5	**The only correct answer is D** (+6) ***A*** *is incorrect because this does not consider the numbers of oxygen and sodium atoms in the compound* ***B*** *is incorrect because this is the number of chromium atoms in the compound* ***C*** *is incorrect because this does not consider the oxidation numbers of sodium and oxygen*	**1**

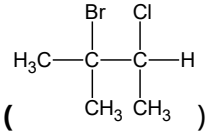
Question Number	Answer	Mark
6	**The only correct answer is C (**N_2O_4) ***A*** *is incorrect because the oxidation number of nitrogen is +1* ***B*** *is incorrect because the oxidation number of nitrogen averages +3* ***D*** *is incorrect because the oxidation number of nitrogen is +5*	**1**

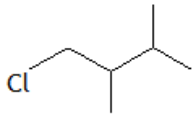
Question Number	Answer	Mark
7	**The only correct answer is D** (Hydrogen unchanged, Oxygen oxidised and reduced) ***A*** *is incorrect because hydrogen is unchanged and oxygen is both oxidised and reduced* ***B*** *is incorrect because hydrogen is unchanged and oxygen is both oxidised and reduced* ***C*** *is incorrect because hydrogen is unchanged and oxygen is both oxidised and reduced*	**1**

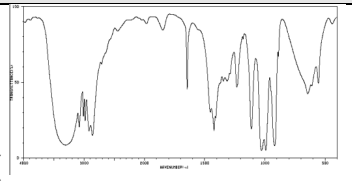
Question Number	Answer	Mark
8	**The only correct answer is B** (II and III) ***A*** *is incorrect because number of protons increasing is not a reason for decreasing ionisation energy down the group* ***C*** *is incorrect because electrons being unpaired is not a reason for decreasing ionisation energy down the group* ***D*** *is incorrect because statements I and IV are not reasons for decreasing ionisation energy down the group*	**1**

Question Number	Answer	Mark
9(a)	**The only correct answer is A** (CH_3CHICH_3) ***B*** *is incorrect because the rate of reaction increases as the carbon-halogen bond strength decreases* ***C*** *is incorrect because the rate of reaction increases as the carbon-halogen bond strength decreases* ***D*** *is incorrect because the rate of reaction increases as the carbon-halogen bond strength decreases*	**1**

Question Number	Answer	Mark
9(b)	**The only correct answer is B** ($CH_3CH_2CBr(CH_3)CH_3$) ***A*** *is incorrect because secondary halogenoalkanes take longer to hydrolyse than tertiary* ***C*** *is incorrect because primary halogenoalkanes take longer to hydrolyse than tertiary* ***D*** *is incorrect because primary halogenoalkanes take longer to hydrolyse than tertiary*	**1**

Question Number	Answer	Mark
10	 **The only correct answer is A (** **)** ***B*** *is incorrect because the bromine and chlorine are on the wrong carbon atoms* ***C*** *is incorrect because there is an additional methyl group* ***D*** *is incorrect because the chlorine and the bromine are on the same carbon atom*	**1**

Question Number	Answer	Mark
11	**The only correct answer is C (**  **)** ***A*** *is incorrect because this is a secondary haloalkane* ***B*** *is incorrect because this is a tertiary haloalkane* ***D*** *is incorrect because this is a secondary haloalkane*	**1**

Question Number	Answer	Mark
12	**The only correct answer is C** () ***A*** *is incorrect because this shows no absorbance for the C=C stretch* ***B*** *is incorrect because this shows no absorbance for the O-H stretch or C=C stretch* ***D*** *is incorrect because this shows no absorbance for the O-H stretch*	**1**

Question Number	Answer	Mark
13	**The only correct answer is B** (CH_3CO^+) ***A*** *is incorrect because the fragment is not present in propanone* ***C*** *is incorrect because the fragment is not present in propanone* ***D*** *is incorrect because the fragment is not present in propanone*	**1**

Question Number	Answer	Mark
14	**The only correct answer is D** (136.9 cm^3) ***A*** *is incorrect because this is the volume of acid required* ***B*** *is incorrect because this is the number of moles of acid multiplied by 1000* ***C*** *is incorrect because this is 150 – (the number of moles of acid multiplied by 1000)*	**1**

Question Number	Answer	Mark
15(a)	**The only correct answer is B** (5) ***A*** *is incorrect because this is the rounded number of grams of NaOH needed* ***C*** *is incorrect because this is the mass of a pellet divided by the moles of NaOH* ***D*** *is incorrect because this is the moles of NaOH multiplied by 1000 and divided by 0.7*	**1**

Question Number	Answer	Mark
15(b)	**The only correct answer is A** (0.0031 mol) ***B*** *is incorrect because this is the moles of sodium hydroxide* ***C*** *is incorrect because the number of moles of NaOH has been doubled instead of halved* ***D*** *is incorrect because this calculation has ignored the sample of 25.0 cm^3*	**1**

Question Number	Answer	Mark
15(c)	**The only correct answer is B** (pink $\rightarrow$ colourless) ***A*** *is incorrect because the indicator would start pink in sodium hydroxide* ***C*** *is incorrect because this is the opposite colour change for methyl orange indicator* ***D*** *is incorrect because this is the colour change for methyl orange* indicator	**1**

Question Number	Answer	Mark
16	**The only correct answer is C** (AgCl and AgBr) ***A*** *is incorrect because AgBr will be soluble but not AgI* ***B*** *is incorrect because AgCl will be soluble but not AgI* ***D*** *is incorrect because AgBr will also be soluble*	**1**

Question Number	Answer	Mark
17	**The only correct answer is C** (5.22 dm^3) ***A*** *is incorrect because this is the number of moles of hydrogen* ***B*** *is incorrect because this is the number of moles of lithium* ***D*** *is incorrect because this is the number of moles of lithium multiplied by the molar volume*	**1**

Total for Section A = 20 marks

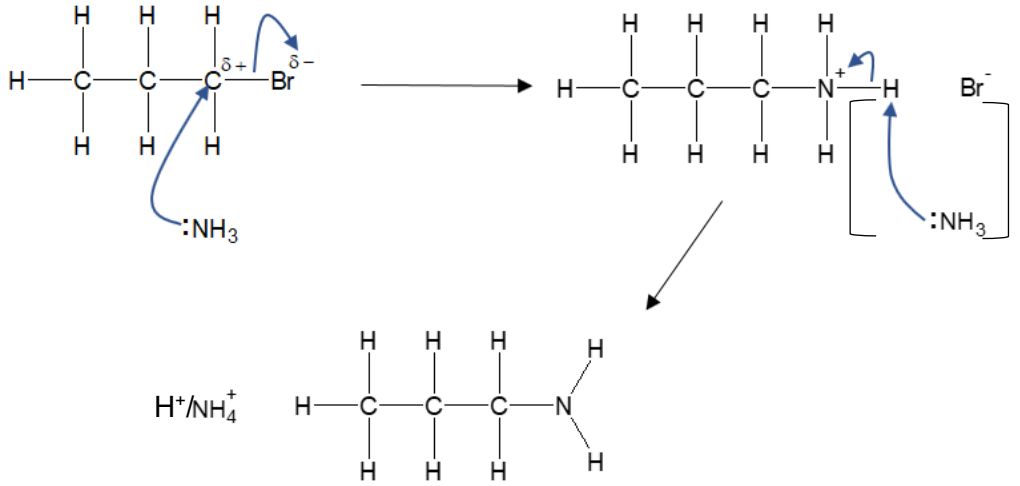
Section B

Question Number	Answer	Additional Guidance	Mark
18(a)	• identification of suitable reagent(s)	50% / concentrated **and** sulfuric acid / H_2SO_4 **and** potassium bromide / KBr Allow Other named bromides Phosphorus **and** bromine Phosphorus(V) bromide / PBr_5 Phosphorus(III) bromide / PBr_3 Thionyl bromide / $SOBr_2$ If the name and the formula are given, then both must be correct Do not award dilute sulfuric acid	**1**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	• conditions	Ethanolic / alcoholic (solution) Allow ethanol / alcohol Ignore heat / solid / reflux Do not award aqueous solution	**1**

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	• C_4H_7N	Allow elements in any order Ignore C_3H_7CN	**1**

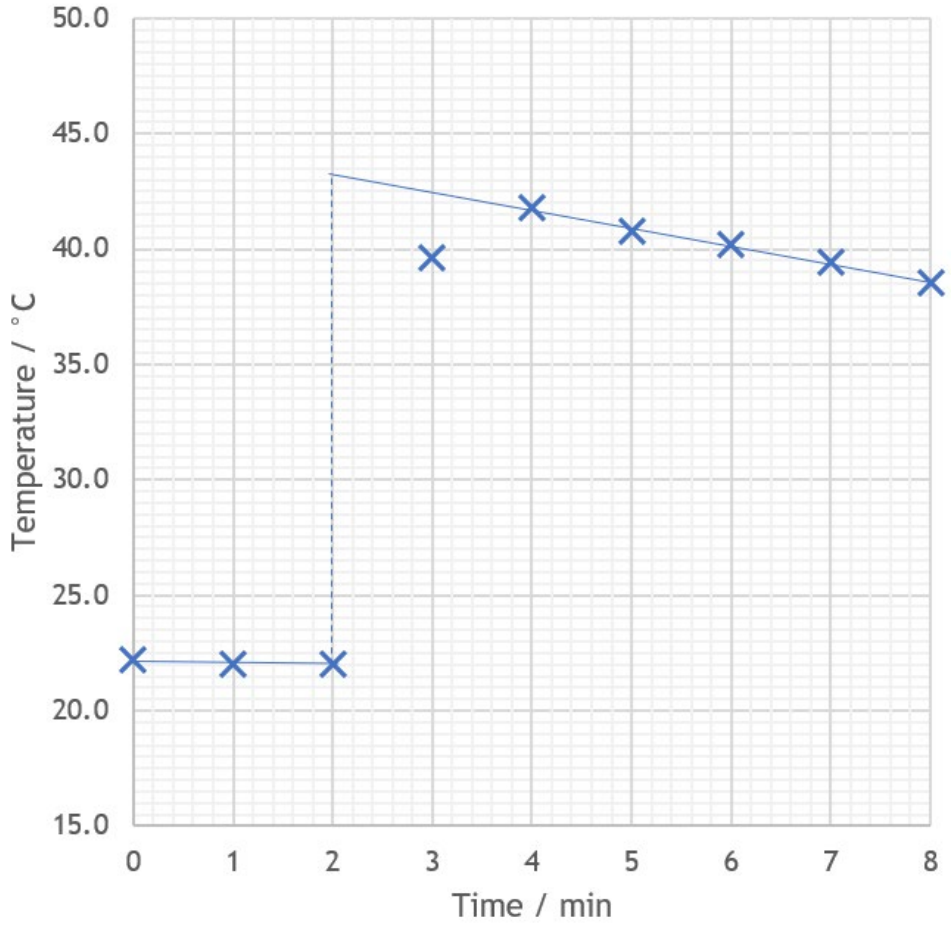
Question Number	Answer	Additional Guidance	Mark
18(b)(iii)	• nucleophilic **(1)** • substitution **(1)**	Allow nucleophile for nucleophilic Mark independently List principle applies (further incorrect answers will each lose a mark) Allow phonetic spelling	**2**

Question Number	Answer	Additional Guidance	Mark
18(b)(iv)	• dipole and arrow from C–Br bond to $Br^{\delta-}$ or just beyond **(1)** • arrow from ammonia to $C^{\delta+}$ **and** 1 or 2 correct curly arrows on intermediate (each from bond or lone pair to atom) **(1)** **(1)** • intermediate with charge **(1)** • ammonium / H^+ **and** bromide ion **OR** HBr **OR** NH_4Br	 Accept bromide and H^+/ammonium ions shown anywhere on answer (i.e. they don't have to be with intermediate and final product respectively) Allow 3rd arrow for M2 to be from bromide lone pair to the hydrogen atom Negative charge on ammonia should be penalised once only Accept correct SN2 mechanism for 4 marks	**4**

Total for Question 18 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)	An answer that makes reference to the following points: • correct balanced equation **(1)** • correct state symbols **(1)**	Example of equation: $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$ OR $Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$ M2 dependent on M1 or near miss (e.g. missing 2 on $2H^+$)	**2**

Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to the following points: • moles calculated correctly for magnesium **(1)** • moles calculated correctly for acid **(1)** • justification of both the reacted moles being the smaller value as a 1:1 stoichiometry (and Mg being in excess) **(1)**	Example answer: 0.5 ÷ 24.3 = 0.020576 moles of Mg Allow use of 24 for 24.3 gives 0.020833 Allow 0.020 Do not award 0.02 0.2 × (25 ÷ 1000) = 0.005 moles of acid 0.005 moles of each react as it is a 1:1 relationship (This can be shown in working/text, but must not be contradicted in final answer) Ignore any further workings e.g. 0.005 + 0.005 = 0.01 TE from equation for stoichiometry	**3**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following points: • suitable choice of scale so that the points cover at least 50% of the grid in both directions and allow for extrapolation AND correct choice of axes suitably labelled including units **(1)** • all points plotted correctly **(1)**	Example of graph:  Allow units in brackets e.g. (min) instead of "/ min" NB Lines do not have to be present for 19(c)(i) Ignore scale breaks between 0 and 20/22 on the y-axis that allow for M1 and M2 to be scored	**2**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	An answer that makes reference to the following points: • two straight lines of best fit with the cooling curve extrapolated back to 2 minutes **(1)** • calculation of temperature change from the graph at 2 minutes **(1)**	<u>Example of calculation</u>: Ignore points 2, 3 and 4 being joined by a line 43.5 – 22.0 = 21.5(°C) TE from the graph in 19(c)(i)	**2**

Question Number	Answer	Additional Guidance	Mark
19(d)	An answer that makes reference to the following points: • recall of equation **(1)** • substitution of correct values **(1)** • conversion to molar quantity **(1)** • correct sign **and** units **(1)**	<u>Example calculation:</u> $\Delta H = (-)mc\Delta T$ $\Delta H = 25 \times 4.18 \times 21.5 = 2246.75$(J) $\Delta H \div 0.005 = (-)449\,350$ (J mol^{-1}) / (–)449 (kJ mol^{-1}) $-449\,350$ J mol^{-1} / -449 kJ mol^{-1} TE throughout and from 19(c)(ii) and 19(a) [– 413.8kJ mol^{-1} scores 4 if 19.8 used as ΔT] If mass of 25.5g is used, then the answer will be $-458\,337$ J mol^{-1} / -458 kJ mol^{-1} for 3 marks Ignore SF except 1SF Ignore rounding Correct answer with sign and units scores (4)	**4**

(Total for Question 19 = 13 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>20 (a)*</td>
<td>
This question assesses the 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>
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</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, 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).

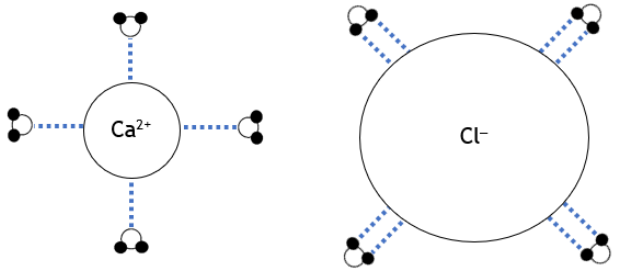
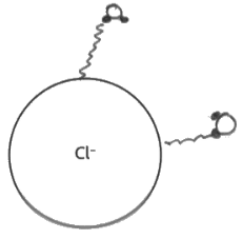
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general, it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning.

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.
</td>
<td>6</td>
</tr>
</table>

	Indicative content: • IP1: fluorine molecules **only** have London forces (instantaneous dipole-induced dipole) between them (as it has a symmetrical electron cloud/is a symmetrical/non-polar molecule.) • IP2: hydrogen chloride is a polar molecule as chlorine is more electronegative than hydrogen. • IP3: HCl forms permanent dipole-permanent dipole interactions in addition to London forces. • IP4: methanol contains a hydrogen attached to a small electronegative element so can form hydrogen bonds (in addition to permanent dipole-permanent dipole interactions and London Forces). • IP5: hydrogen bonds are the strongest intermolecular forces so take the most energy to break. • IP6: London forces are the weakest intermolecular forces, so fluorine has the lowest boiling temperature.	Allow dispersion forces / van der Waals forces Allow no dipole-dipole forces in place of "only" Allow H and Cl have different electronegativities Allow just "permanent dipole interactions" Allow oxygen in place of the small electronegative element Energy and boiling temperature need only be referenced once each in relation to H-bonds and/or London forces in order to gain IP5 and IP6 Allow reverse arguments for IP5 and IP6 Ignore references to shapes, sizes and surface areas	

Question Number	Answer	Additional Guidance	Mark
20(b)	An answer that makes reference to the following points: **(1)** • the oxygen is closest to the calcium ion **(1)** • the hydrogen is closest to the chloride ion	(A minimum of two water molecules should be drawn for each ion – penalise once only) E.g.  Allow displayed formula of water Allow diagrams without dotted lines Allow only one hydrogen of each water molecule closest to the chloride e.g.  A singular water molecule correctly orientated between the ions scores 1 Dipoles are not required but if shown they must be correct Incorrectly labelled dipoles as charges should be penalised once, whether on water (or conversely on ions) Do not award O_2H, but if molecules are unshaded assume they are H_2O	**2**

Question Number	Answer	Additional Guidance	Mark
20(c)	An answer that makes reference to the following points: • Iodine has more electrons (per molecule) (than bromine) **(1)** • so stronger London forces between molecules / I_2 (mean a higher melting temperature for iodine) **(1)**	Accept reverse arguments. If numbers of electrons are given they must be correct for molecules, not the atoms. Accept stronger van der Waals/induced dipole-induced dipole forces / dispersion forces Do not award between atoms Allow "between iodine"	**2**

(Total for Question 20 = 10 marks)

Question Number	Answer		Additional Guidance	Mark
21 (a)			Example of a calculation:	**4**
	• calculation of mass of oxalate remaining	**(1)**	6.0 × 0.3 = **1.8** (g) will remain as oxalate	
	• 4.2 g will decompose to carbonate	**(1)**	6.0 – 1.8 = **4.2** (g) will decompose	
	• M_r of oxalate and carbonate used to give mass of carbonate	**(1)**	(4.2 ÷ 112.3) × 84.3 = **3.15** (g)	
	• final answer	**(1)**	3.15 + 1.8 = **4.95** (g)	
	Alternative method 1:			
	• calculate moles of oxalate	**(1)**	6.0 ÷ 112.3 = **0.0534** (mol)	
	• calculate 70%	**(1)**	0.7 × 0.0534 = **0.0374** (mol)	
	• calculation of M_r of CO and mass lost	**(1)**	28 × 0.0373 = **1.047** (g)	
	• subtract from original mass	**(1)**	6.0 – 1.047 = **4.95**(3) (g)	
	Alternative method 2:			
	• calculate mass that has decomposed	**(1)**	6.0 × 0.7 = **4.2** (g)	
	• calculate moles that have decomposed	**(1)**	(4.2 ÷ 112.3) = **0.0374** (mol)	
	• calculate mass of carbonate	**(1)**	0.0374 × 84.3 = **3.15** (g)	
	• addition of remaining solid	**(1)**	3.15 + (6 – 4.2) = **4.95** (g)	
	continued on next page			

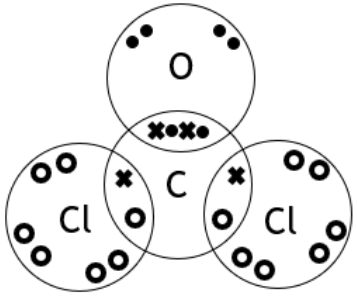
	Alternative method 3: • M_r of CO and oxalate • calculation of mass of CO • 70% of mass of CO • subtraction of mass of CO	**(1)** **(1)** **(1)** **(1)**	28 **and** 112.3 6.0 × (28 ÷ 112.3) = **1.496** (g) 1.496 × 0.7 = **1.047** (g) 6.0 – 1.047 = **4.95**(3) (g) Ignore SF Correct answer scores 4	

Question Number	Answer	Additional Guidance	Mark
21 (b)	An answer that makes reference to the following points: • the temperature of decomposition of carbonates / stability increases down the group **(1)** • (this is because) the size of the cation increases but has the same charge **(1)** • so is less polarising (of the C–O bond) **(1)**	Accept reverse arguments Allow charge density decreases (down the group) The trend down the group must be mentioned for all 3 marks to be awarded	**3**

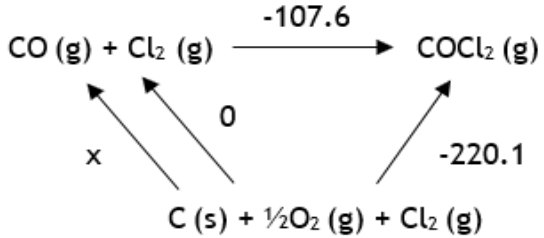
Question Number	Answer	Additional Guidance	Mark
21 (c)	An answer that makes reference to the following points: • the magnesium carbonate may begin to decompose (before the oxalate decomposition is complete).	Allow the sample would be contaminated with magnesium oxide	**1**

(Total for Question 21 = 8 marks)

Section C

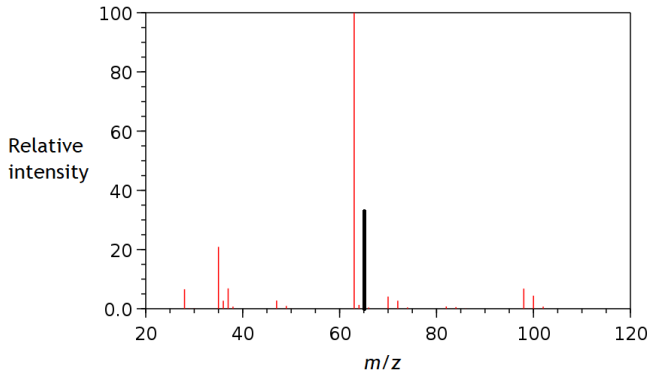
Question Number	Answer	Additional Guidance	Mark
22(a)	An answer that makes reference to the following points: A diagram that includes: • carbon singly covalently bonded to two chlorine atoms and three lone pairs on each chlorine **(1)** • carbon doubly bonded to an oxygen atom and two lone pairs on the oxygen **(1)**	 Penalise lack of lone pairs once only Allow any representation of electrons Allow individual electrons spread out, rather than in pairs Allow horizontal shared pairs of electrons Ignore lines representing covalent bonds	**2**

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	An explanation that makes reference to the following points: Any two pairs from the three: • decrease the temperature **(1)** • as the (forward) reaction is exothermic **(1)** • increase the pressure **(1)** • as there a fewer moles of (gas) on the product side **(1)** **EITHER** • remove the phosgene (as it is formed) **(1)** • to reduce the concentration of product (so equilibrium moves to the right) **(1)** **OR** • add more CO / Cl_2 **(1)** • to increase the concentration of the reactants (so equilibrium moves to the right) **(1)**	Ignore references to rate of reaction Allow T↓ Allow "favours the exothermic reaction" Allow P↑ if numbers are quoted, they must be 2:1 Allow "favours the side with fewer moles"	**4**

Question Number	Answer	Additional Guidance	Mark
22 (b)(ii)	An answer that makes reference to the following points: • correct species **(1)** • correct state symbols **(1)** • correct arrows **(1)** • calculation of value **(1)**	Example of an answer:  ΔH_f CO = −220.1 – (−107.6) = −112.5 (kJ mol^{-1}) Accept state symbol for C(s, graphite) Ignore absence of arrow and value to chlorine Numbers are not required on the cycle	**4**

Question Number	Answer	Additional Guidance	Mark
22(c)(i)	An explanation that makes reference to the following points: • chlorine isotopes (35 and 37) are in the ratio of 3:1 **(1)** • (as there are) two chlorine atoms give the ratio of 9:6:1 **(1)**	Accept ^{37}Cl 75% : ^{35}Cl 25% Allow this shown in workings e.g. $CO^{37}Cl^{37}Cl^{(+)}$ = 102, $CO^{35}Cl^{37}Cl^{(+)}$ = 100, $CO^{35}Cl^{35}Cl^{(+)}$ = 98 Do not award ^{36}Cl Mark independently Reference to isotopes of carbon should be penalised once	**2**

Question Number	Answer	Additional Guidance	Mark
22(c)(ii)	An answer that makes reference to the following point • $CO^{35}Cl^{+}$	Allow the + on any of the atoms Ignore brackets	**1**

Question Number	Answer	Additional Guidance	Mark
22(c)(iii)	An answer that makes reference to the following point • peak drawn at 65 with relative intensity of 33.3	Example of completed graph:  Allow a peak height between 30-35	**1**

Question Number	Answer	Additional Guidance	Mark
22 (d)	An answer that makes reference to the following points: • 1795 (cm^{-1}) **(1)** • (from the) C=O (stretching vibrations) **(1)**	Allow a number or range within 1630-1850 (cm^{-1}) M2 is dependent on M1 Allow a number or range within 550-850 (cm^{-1}) **and** C-Cl (stretching vibrations) for 2 marks Ignore acyl chloride Do not award M2 for aldehydes/ketones	**1**

Question Number	Answer	Additional Guidance	Mark
22(e)(i)	An answer that makes reference to the following point: • balanced equation	$2CHCl_3 + O_2 \rightarrow 2COCl_2 + 2HCl$ Accept multiples of the equation Ignore state symbols even if incorrect	**1**

Question Number	Answer	Additional Guidance	Mark
22(e)(ii)	An answer that makes reference to the following point: • oxygen concentration will decrease	Allow oxygen used up Allow [O_2] decreases Allow volume of oxygen decreases Do not award "air is used up" "Reactants are used up" is insufficient as doesn't apply information from the question Comments about trichloromethane decreasing negate the oxygen mark	**1**

Question Number	Answer	Additional Guidance	Mark
22(e)(iii)	An answer that makes reference to the following point • use a fume cupboard (due to toxic and irritant gases)	Allow open in a well-ventilated laboratory / open outside / wear a **gas** mask Ignore eye protection / laboratory coats / gloves Ignore just "mask" and "do not inhale" Do not award face shield	**1**

Question Number	Answer	Additional Guidance	Mark
22(e)(iv)	An answer that makes reference to the following points: • no, because some of the $HCl/COCl_2$ may have dissolved into the chloroform / be trapped as bubbles in the liquid	 Allow may have reacted (with oxygen) to give (toxic) phosgene / $COCl_2$	**1**

(Total for Question 22 = 20 marks)
Total for Section C = 20 marks
Total for Paper = 80 marks