GradeMax

Pearson

Mark Scheme (Results)

January 2026

Pearson Edexcel International Advanced Subsidiary Level in Chemistry
Paper 01: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

WCH12/01

GradeMax

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January 2026
Question Paper Log Number P79051A
Publication Code WCH12_01_2601_MS
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Answer	Mark
1	**The only correct answer is A** (the activation energy for the backward reaction is +70 kJ mol^{-1}) ***B*** *is incorrect because the enthalpy change for the backward reaction is +40 kJ* mol^{-1} ***C*** *is incorrect because this enthalpy change for the forward reaction is −40 kJ* mol^{-1} ***D*** *is incorrect because the enthalpy change for the forward reaction is −40 kJ* mol^{-1}	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** (always positive always negative positive or negative) ***A*** *is incorrect because the enthalpy change of atomisation is always positive* ***B*** *is incorrect because the enthalpy change of combustion is always negative and the enthalpy change of formation is positive or negative* ***D*** *is incorrect because the enthalpy of atomisation is always positive and the enthalpy change of formation is positive or negative*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is A** (50 × 4.18 × 13.5) ***B*** *is incorrect because in the calculation the expression includes divided by 13.5 not multiplied by 13.5* ***C*** *is incorrect because in the calculation the temperature rise should be used not the maximum temperature* ***D*** *is incorrect because in the calculation the temperature rise should be used not the maximum temperature and in the calculation the expression should be multiplied by 13.5*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** (-31 kJ mol^{-1}) ***A*** *is incorrect because the enthalpy change of formation of carbon dioxide must be subtracted from the enthalpy change of formation of methanoic acid* ***C*** *is incorrect because the enthalpy change of formation of carbon dioxide must be subtracted from the enthalpy change of formation of methanoic acid* ***D*** *is incorrect because the enthalpy change of formation of carbon dioxide must be subtracted from the enthalpy change of formation of methanoic acid*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is A** (ammonia, NH_3) ***B*** *is incorrect because liquid hydrogen bromide cannot form hydrogen bonds with itself* ***C*** *is incorrect because liquid hydrogen sulfide cannot form hydrogen bonds with itself* ***D*** *is incorrect because liquid silane cannot form hydrogen bonds with itself*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is B** (hydrogen bromide, HBr) ***A*** *is incorrect because ammonia has fewer electrons than hydrogen bromide so has weaker London forces* ***C*** *is incorrect because hydrogen sulfide has fewer electrons than hydrogen bromide so has weaker London forces* ***D*** *is incorrect because silane has fewer electrons than hydrogen bromide so has weaker London forces*	**(1)**

Question Number	Answer	Mark
5(c)	**The only correct answer is D** (silane, SiH_4) ***A*** *is incorrect because ammonia has a permanent dipole* ***B*** *is incorrect because hydrogen bromide has a permanent dipole* ***C*** *is incorrect because hydrogen sulfide has a permanent dipole*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (Na_2SO_3) ***B*** *is incorrect because the sulfur in B is, on average, +3, but in A is +4* ***C*** *is incorrect because the sulfur in C is, on average, +3.3, but in A is +4* ***D*** *is incorrect because the sulfur in D is, on average, +2.5, but in A is +4*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is B** (gains electrons and is reduced) ***A*** *is incorrect because the oxidising agent is reduced* ***C*** *is incorrect because the oxidising agent gains electrons and is reduced* ***D*** *is incorrect because the oxidising agent gains electrons*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is D** ($MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$) ***A*** *is incorrect because Mn(VI) is both oxidised to Mn(VII) and reduced to Mn(IV)* ***B*** *is incorrect because Cu(I) is both oxidised to Cu(II) and reduced to Cu(0)* ***C*** *is incorrect because I(I) is both oxidised to I(V) and reduced to (−I)*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is C** (6) ***A*** *is incorrect because 6 electrons will balance the charge in the equation, not 4 as Cl goes from +5 to −1* ***B*** *is incorrect because 6 electrons will balance the charge in the equation, not 5 as Cl goes from +5 to −1* ***D*** *is incorrect because 6 electrons will balance the charge in the equation, not 7 as Cl goes from +5 to −1*	**(1)**

Question Number	Answer	Mark
10(a)	**The only correct answer is D** (removing the ammonia as it is formed) ***A*** *is incorrect because decreasing the size of the catalyst pieces increases surface area increasing the rate* ***B*** *is incorrect because increasing the pressure results in an increasing rate of collisions with the same percentage of successful collisions* ***C*** *is incorrect because increasing the temperature increases the rate of collisions and the percentage which are successful*	**(1)**

Question Number	Answer	Mark
10(b)	**The only correct answer is C** ($4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$) ***A*** *is incorrect because the oxidation number of nitrogen changes from +2 to +4* ***B*** *is incorrect because the oxidation number of nitrogen changes from +4 to +5* ***D*** *is incorrect because the oxidation number of nitrogen changes from −3 and +2 to 0*	**(1)**

Question Number	Answer	Mark
10(c)	**The only correct answer is B** (at a lower temperature the catalyst does not work efficiently) ***A*** *is incorrect because at a lower temperature the yield of* SO_3 *would increase* ***C*** *is incorrect because at a higher pressure the yield of* SO_3 *would increase* ***D*** *is incorrect because the cost of reaction vessels would increase at a higher pressure*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is C** (value C) ***A*** *is incorrect because this is the number of particles with the most probable energy at the lower temperature* ***B*** *is incorrect because this is the number of particles with the most probable energy at the higher temperature* ***D*** *is incorrect because this is the most probable energy of particles at the higher temperature*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is D** (increasing the pH of the solution) ***A*** *is incorrect because as the* V^{3+} *is removed the equilibrium position will shift to make more 3+ leaving the colour less purple* ***B*** *is incorrect because addition of acid will shift the equilibrium position to the right making the solution greener* ***C*** *is incorrect because allowing hydrogen to escape will shift the equilibrium position to the right making the solution greener*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is D** (it exists as two pairs of *cis-trans* isomers) ***A** is incorrect because the alcohol is a primary alcohol so can be oxidised* ***B** is incorrect because the structure does have three CH_3 groups and three CH_2 groups* ***C** is incorrect because bromine can react with the carbon-carbon double bonds (−C=C−)*	**(1)**

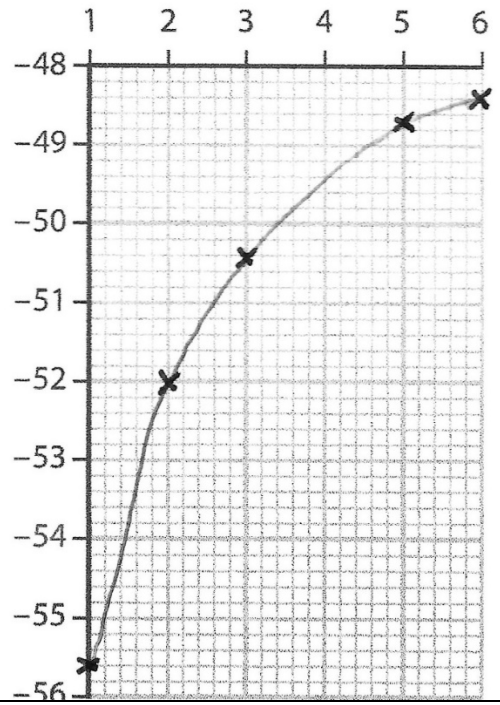
Question Number	Answer	Mark
14	**The only correct answer is B** (aldehydes, carboxylic acids and ketones only) ***A** is incorrect because ketone groups can form from the secondary alcohols (in the middle of the molecule)* ***C** is incorrect because the alcohol groups at the end of the molecule are primary so can oxidise to aldehydes or carboxylic acids* ***D** is incorrect because all the alcohol groups in the compound can be oxidised as none are tertiary*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is D** (yellow purple) ***A** is incorrect because the lower layer will be a yellow dilute aqueous solution and iodine is purple in cyclohexane* ***B** is incorrect because these are the correct colours if cyclohexane was denser than water* ***C** is incorrect because iodine is purple in cyclohexane*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is A** (ir 1 and ms 1) ***B*** *is incorrect because ir 1 is 2-iodopropane with no distinguishing peaks compared to the data booklet and ms 2, is propanone, and does not have a peak at m/z = 170* ***C*** *is incorrect because ir 2 is propan-2-ol and ms 1 has a peak at m/z = 170 so is 2-iodopropane* ***D*** *is incorrect because ir 2 is propan-2-ol and ms 2 does not have a peak at 60 but at 58 so is propanone*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
17(a)	• points plotted to within ±½ square **(1)** • curve passing through or close to all five points **(1)**	Example of graph NOTE Axis labels have been missed off for clarity 	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(b)	• value of enthalpy change for combustion of 1 g of butane from the graph **to 3SF** **(1)** • calculation of enthalpy change of combustion for 1 mol **(1)**	Marks may be awarded from values in the table Ignore units, even if incorrect Penalise omission of negative sign once only **M1 dependent on some attempt at a line in (a)** −49.4 (kJ) Allow ±½ square (ie 0.1 kJ) Ignore omission of construction lines If working is not shown, check the value from the line **M2 dependent on value from M1** Example of calculation (−49.4 ÷ (1/58) = −49.4 × 58 =) −2865.2 / −2865 (kJ mol^{-1}) TE on any value from M1 Answer must be to 3SF or more	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(c)	An explanation that makes reference to the following points: • (because) for each increase of carbon chain by 1 there is 1 more C−C bond and 2 more C−H bonds broken (and 1½ O=O bonds broken) **(1)** • and two more C=O and two more O−H bonds made **(1)**	Ignore number of O=O bonds If no other mark awarded, bonds broken are C−C and C−H (and O=O) **and** bonds formed are C=O and O−H Or the difference (between successive members) is due to (combustion of) CH_2 so remains the same/constant/similar scores (1)	**(2)**

(Total for Question 17 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)	An explanation that makes reference to the following points: • (bromine has) one more shell (of electrons) than chlorine Or more shielding/repulsion by inner electrons than chlorine Or a larger atomic radius than chlorine **(1)** • (bromine has) one more proton (in the nucleus) than selenium (and the same/similar shielding) **(1)** • (bromine has) lower attraction for (bonded/shared/a pair of) electron(s) than chlorine Or higher attraction for (bonded/shared/a pair of) electron(s) than selenium **(1)**	Accept reverse arguments throughout Ignore any reference to ionic radius Ignore any reference to polarisation Allow atomic radius increases down group Allow higher effective nuclear charge Allow higher nuclear charge Allow nuclear charge increases across period Ignore (bromine has a) smaller atomic radius than selenium Ignore attraction for outer(most) electrons Ignore any reference to gaining electrons If no other mark awarded, electronegativity decreases down a group **and** increases across a period scores (1)	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	An answer that makes reference to the following points: • cream/off-white precipitate **(1)** • equation including state symbols **(1)** • precipitate dissolves **(1)**	Allow ppt/ppte/solid for precipitate Allow creamy-white Do not award yellow $Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ Allow precipitate is soluble Allow precipitate disappears Allow (clear/colourless) solution forms	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	An answer that makes reference to two of the following points: • misty/steamy fumes (of HBr) **(1)** • brown (fumes/gas of Br_2) **(1)** • choking fumes/gas/smell (of SO_2) **(1)** • solid/KBr disappears/dissolves **(1)**	Penalise incorrect species once only Ignore white Allow red or orange for brown Ignore yellow Ignore liquid/solution Allow pungent for choking Ignore effervescence/fizzing/bubbling Do not award rotten egg smell	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)(iii)	An answer that makes reference to the following points: • (solution turns) orange/yellow **(1)** • equation **(1)**	 Do not award solution turns brown or green Do not award any reference to fumes Ignore green (chlorine) gas disappears Ignore bubbles (of chlorine gas) $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ Ignore state symbols, even if incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)	• calculation of number of moles of iodine formed **(1)** • calculation of number of moles of bromine formed **(1)**	<u>Example of calculation</u> n = 0.330 ÷ 2 = 0.165 (mol) (chlorine is the limiting reagent so) n = 0.250 − 0.165 = 0.085 (mol) Or (moles of chloride ions formed from bromide ions) n = 0.500 − 0.330 = 0.17 moles **and** (so moles of bromine formed) n = 0.17 ÷ 2 = 0.085 (mol) If no other mark awarded, values of bromine and iodine, with neither greater than 0.165, that add to make 0.250 moles scores (1)	**(2)**

(Total for Question 18 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)	An explanation that makes reference to the following points: • iodine monochloride/ICl has London forces (as the strongest intermolecular force) **(1)** • water/H_2O has hydrogen bonds/H-bonds (as the strongest intermolecular force) **(1)** • the intermolecular forces (in ICl and H_2O) are similar in strength / require a similar amount of energy to break **(1)**	Accept instantaneous-induced dipole-dipole forces Accept dispersion forces Allow van der Waals forces Ignore id-id/vdw without explanation Ignore (permanent) dipole-dipole forces Ignore (permanent) dipole-dipole forces Ignore London forces Allow intermolecular forces in water/H_2O are slightly stronger / require only a little more energy to break (than in iodine monochloride/ICl)	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(b)(i)	• calculation of bonds broken **(1)** • calculation of I−Cl bond enthalpy **(1)**	Correct answer with no working scores (2) Ignore units, even if incorrect <u>Example of calculation</u> 151 + 243 = 394 Do not award 2 × 151 + 2 × 243 = 788 Do not award ½ × 151 + ½ × 243 = 197 (394 + 30) ÷ 2 = 212 (kJ mol^{-1}) TE on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	Either • construction of Hess's law cycle based on equations given in the question **(1)** • calculation of enthalpy change for the equation **(1)** • calculation of enthalpy change of formation **(1)** Or • construction of Hess's law cycle based on enthalpy of formation **(1)** • division of all values by 2 **(1)** • calculation of enthalpy change of formation **(1)**	Ignore units, even if incorrect Example of calculation $I_2(s) + Cl_2(g) \rightarrow 2ICl(s)$ $\downarrow \qquad \uparrow$ $I_2(g) + Cl_2(g) \rightarrow 2ICl(g)$ (+)62 + −30 + −102 = −70 (kJ) No TE on an incorrect Hess's law cycle −70 ÷ 2 = −35 (kJ mol^{-1}) TE on a correct Hess's law cycle with a single transcription error $\frac{1}{2}I_2(s) + \frac{1}{2}Cl_2(g) \rightarrow ICl(s)$ $\downarrow \qquad \uparrow$ $\frac{1}{2}I_2(g) + \frac{1}{2}Cl_2(g) \rightarrow ICl(g)$ (+)62 ÷ 2 = (+)31 (kJ) **and** −30 ÷ 2 = −15 (kJ) **and** –102 ÷ 2 = −51(kJ) No TE on an incorrect Hess's law cycle (+)31 + −15 + −51 = −35 (kJ) TE on a correct Hess's law cycle with a single transcription error Values may be seen on the Hess's law cycles Correct answer with no working scores (3)	**(3)**

(Total for Question 19 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)	An explanation that makes reference to the following points: • magnesium ion/Mg^{2+} is smaller (than strontium ion/Sr^{2+}) Or magnesium ion/Mg^{2+} has a higher charge density (than strontium ion/Sr^{2+}) **(1)** • electron cloud more distorted in carbonate ion/anion (with magnesium) Or magnesium (ion/cation) more polarising **(1)** • so weak(er) carbon-oxygen/C–O bond (with magnesium) **(1)**	Accept reverse arguments **M1 dependent on some indication of ions** Allow cation is smaller (in magnesium carbonate) Allow ionic radius increases down the group Allow cation has higher charge density (in magnesium carbonate) Allow charge density of cation decreases down the group Do not award magnesium carbonate/$MgCO_3$/it for magnesium ion/Mg^{2+} in M1 Allow electrons in carbonate ion/anion more attracted (to cation) Allow carbonate ion/anion more polarised Ignore just carbonate ion/anion more distorted Accept less energy needed to break the carbon-oxygen/C–O bond Allow easier to break carbon-oxygen/C–O bond Allow weak(er) bonds in the carbonate ion/anion Do not award weak(er) ionic bond If no other mark awarded, thermal stability increases down the group scores (1)	**(3)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*20(b)</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 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
3 or 4 indicative points would get 1 reasoning mark
0, 1 or 2 indicative points would get zero reasoning marks

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>
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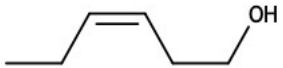
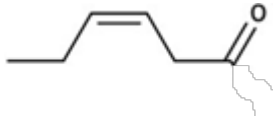
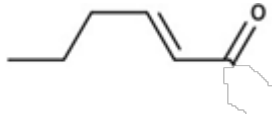
	Indicative content **IP1** weigh the test tube (empty) **and** (reweigh) after adding some (solid) carbonate/**Q**CO_3 **IP2** heat (the solid in the test tube using the Bunsen burner) **IP3** until there is no change in mass **IP4** calculate moles of carbon dioxide (which is equal to the moles of **Q**CO_3/**Q**O) from the loss in mass and molar mass/M_r/44 **IP5** calculate the molar mass/M_r of **Q**CO_3 from (initial) mass and moles (of **Q**CO_3/**Q**O/CO_2) Or calculate the molar mass/M_r of **Q**O from (remaining) mass and moles (of **Q**CO_3/**Q**O/CO_2) **IP6** calculate the molar mass/A_r of **Q** (allowing its identification) from subtraction of 60/CO_3 from the molar mass/M_r of **Q**CO_3) / from subtraction of 16/O from the molar mass/M_r of **Q**O	Ignore any reference to a flame test Allow place test tube on balance and zero Allow weigh specimen tube before and after adding some (solid) carbonate/**Q**CO_3 to the test tube Do not allow crucible for test tube in IP1 Allow place (tube) in (Bunsen) flame in IP2 Do not allow heating of solution in IP2 Do not allow combustion/burning in IP2 Ignore until no more carbon dioxide given off Ignore until reaction finishes Note: heat to constant mass scores IP2 and IP3 Do not allow calculate moles of carbon dioxide from a volume measured in a gas syringe/over water Alternative route to IP5 and IP6: IP5 calculate mass of **Q** in **Q**O by subtracting mass of O (from moles × 16) from mass of **Q**O Or calculate mass of **Q** in **Q**CO_3 by subtracting mass of CO_3 (from moles × 60) from mass of **Q**CO_3 IP6 calculate the molar mass/A_r of **Q** (allowing its identification) by dividing mass of **Q** by moles (of **Q**CO_3/**Q**O/CO_2)	

Question Number	Answer		Additional Guidance	Mark
20(c)			Allow TE throughout Ignore SF except in A_r of **Q** which should be to ≥2 SF Ignore units, even if incorrect Just A_r = 87.6 and **Q** is strontium/Sr with no working scores (0) <u>Example of calculation</u>	**(5)**
	• calculation of initial moles of hydrochloric acid	**(1)**	n = 50 ÷ 1000 × 0.400 = 0.0200 (mol)	
	• calculation of moles of sodium hydroxide / excess hydrochloric acid	**(1)**	n = 32.25 ÷ 1000 × 0.200 = 0.00645 (mol)	
	• calculation of moles of acid used	**(1)**	n = 0.0200 − 0.00645 = 0.01355 (mol)	
	• calculation of moles of **Q**CO_3 **and** calculation of M_r of **Q**CO_3 Or calculation of mass of **Q** in **Q**CO_3	**(1)**	n = 0.01355 ÷ 2 = 0.006775 **and** M_r = 1.00 ÷ 0.006775 = 147.60 Or mass = 1.00 – 0.006775 × 60 = 0.5935 (g)	
	• calculation of A_r of **Q** **and** identity of **Q**	**(1)**	A_r = 147.60 − 60 = 87.6 Or A_r = 0.5935 ÷ 0.006775 = 87.6 **and** So **Q** is strontium/Sr	

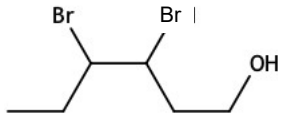
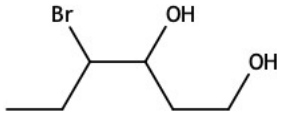
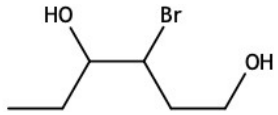
(Total for Question 20 = 14 marks)

TOTAL FOR SECTION B = 40 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
21(a)	• structure of *Z*-hex-3-enal **(1)** • structure of *E*-hex-2-enal **(1)**	Skeletal structure of *Z*-hex-3-en-1-ol:  Skeletal structure of *Z*-hex-3-enal:  Skeletal structure of *E*-hex-2-enal:  Do not award *E*-hex-3-enal Do not award *E*-hex-4-enal Ignore bond lengths and bond angles Penalise non-skeletal structures once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(b)	An explanation that makes reference to the following points: • (structural isomers as) same molecular formula / both $C_6H_{10}O$ **(1)** • (not geometric isomers as) the double bond/C=C is in a different position **(1)**	Allow contain the same number of each type of atom Ignore same empirical formula Allow they are position isomers Allow they have different groups attached to the double bond/C=C Ignore any reference to C=C bond rotation Ignore any reference to *E*/*Z* isomers	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(c)(i)	An answer that makes reference to the following point: • 	Accept  Or  Allow structural or displayed formula or any combination Ignore connectivity of OH group Ignore bond lengths and bond angles Do not award molecular formula	(1)

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	An answer that makes reference to the following points: • PCl_5 **(1)** • misty/steamy fumes (of HCl) **(1)** Or • potassium dichromate((VI))/$K_2Cr_2O_7$ **and** sulfuric acid/H_2SO_4 **(1)** • colour change from orange to green **(1)**	**M2 dependent on M1 or near miss (eg PCl_3 or dichromate)** Allow fumes/gas turns (damp) blue litmus (paper) red Allow fumes/gas form white smoke with (conc.) ammonia Do not award just white smoke Allow acidified potassium/sodium dichromate((VI)) Allow acidified dichromate / $Cr_2O_7^{2-}$ **and** H^+ Do not award acidified manganate	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(d)	A description that makes reference to the following points: • (heat with) potassium dichromate((VI))/$K_2Cr_2O_7$ **and** sulfuric acid/H_2SO_4 **(1)** • distil **(1)** • so (aldehyde) is not oxidised further/does not form a carboxylic acid **(1)**	Allow acidified potassium/sodium dichromate((VI)) Allow acidified dichromate / $Cr_2O_7^{2-}$ **and** H^+ M1 may be awarded from a labelled diagram Allow fractional distillation Allow any diagram showing a distillation apparatus Do not award reflux **M3 dependent on M2** Allow (so) partial oxidation (of alcohol) Allow any indication that the aldehyde is removed before being further oxidised	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(e)	An explanation that makes reference to the following points: • alcohols are primary, secondary or tertiary **(1)** • a primary alcohol has two (or three) hydrogens attached to the carbon with the −OH attached **and** a secondary alcohol has one hydrogen attached to the carbon with the −OH attached **and** a tertiary alcohol has no hydrogens attached to the carbon with the −OH attached Or a primary alcohol has one (or no) carbon/R group attached to the carbon with the −OH attached **and** a secondary alcohol has two carbon/R groups attached to the carbon with the −OH attached **and** a tertiary alcohol has three carbon/R groups attached to the carbon with the −OH attached **(1)** • example of any primary alcohol **and** any secondary alcohol **and** any tertiary alcohol **(1)** • all examples of alcohols are saturated **and** non-cyclic **and** contain six carbon atoms **(1)**	Ignore any reference to carbocations and/or stability Ignore any reference to oxidation Allow 1°, 2° or 3° M1 may be subsumed in the descriptions in M2 Allow primary is RCH_2OH **and** secondary is R_2CHOH **and** tertiary is R_3COH Allow exemplification of alcohols by structure or name in M3 and M4 (if both given all must be correct) M4 dependent on each type of alcohol being present In M3 and M4, penalise the same mistake once only (eg horizontal C–HO connectivity, incorrect name, or missing hydrogen atoms on displayed formulae)	**(4)**

Question Number	Answer	Additional Guidance	Mark
21(f)(i)	• correct equation	$(CH_3)_2CClCH_2CH_2CH_3 + KOH \rightarrow (CH_3)_2COHCH_2CH_2CH_3 + KCl$ Allow NaOH and NaCl for KOH and KCl Allow H_2O and HCl for KOH and KCl Or $(CH_3)_2CClCH_2CH_2CH_3 + OH^- \rightarrow (CH_3)_2COHCH_2CH_2CH_3 + Cl^-$ The OH group in the product may be shown in brackets, $(CH_3)_2C(OH)CH_2CH_2CH_3$ Allow skeletal formula for alcohol Do not award molecular formula or $C_6H_{13}OH$ for alcohol	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(f)(ii)	An answer that makes reference to the following point: • acts as a nucleophile	Allow electron pair donor Allow to attack the δ+ carbon Ignore just nucleophilic substitution Ignore just to substitute/displace the Cl Do not award other incorrect answers, eg base / oxidising agent	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(f)(iii)	An answer that makes reference to the following points: (condition to produce an alcohol) • an aqueous solution **(1)** (condition to produce a mixture of alkenes) • an ethanolic solution **(1)**	Ignore any reference to temperature/heat/concentration/catalyst Allow water Allow aqueous ethanol Allow alcohol Do not award ethanoic Do not award aqueous ethanol	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(f)(iv)	An explanation that makes reference to the following points: • hydrogen may be removed from the 1-position or 3-position Or hydrogen may be removed from either side of the carbon bonded to chlorine **(1)** • forming a 1-ene or a 2-ene Or forming the double bond between the first and second carbons or the second and third carbons Or forming 2-methylpent-1-ene or 2-methylpent-2-ene **(1)**	Ignore any reference to carbocations Ignore any reference to major and minor products Accept a suitable diagram showing the two hydrogens that may be removed Allow hydrogen removed from either side of the carbon bonded to the methyl group(s) Allow proton for hydrogen in M1 Accept a suitable diagram showing where the double bonds may form Allow double bond can form on either side of the carbon bonded to chlorine/methyl group(s) Allow names or structures Do not award M2 for any reference to the two alkenes being *E*/*Z* or cis/trans isomers If no other mark awarded, hydrogen can be removed from two places **and** so double bond can form in two places scores (1)	**(2)**

(Total for Question 21 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS