

**GCE**

**Chemistry A**

**H032/01: Breadth in chemistry**

Advanced Subsidiary GCE

**Mark Scheme for Autumn 2021**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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## 1. Annotations

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

2. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

<b>Annotation</b>	<b>Meaning</b>
<b>DO NOT ALLOW</b>	Answers which are not worthy of credit
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	Or reverse argument

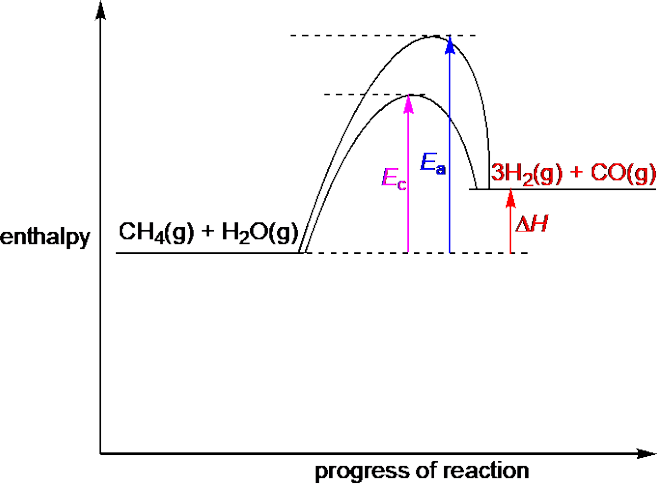
## SECTION A

Question	Answer	Marks	AO element	Guidance
1	C	1	AO1.2	
2	A	1	AO2.1	
3	D	1	AO1.1	
4	C	1	AO1.2	
5	C	1	AO2.2	
6	D	1	AO2.4	
7	B	1	AO2.3	
8	C	1	AO1.2	
9	D	1	AO1.2	
10	A	1	AO2.6	
11	A	1	AO1.1	
12	C	1	AO1.1	
13	B	1	AO2.5	<b>ALLOW 4</b>
14	B	1	AO1.1	
15	D	1	AO2.1	
16	B	1	AO1.2	
17	B	1	AO1.2	
18	C	1	AO2.2	
19	B	1	AO1.1	
20	A	1	AO2.1	
	<b>Total</b>	<b>20</b>		

## SECTION B

Question		Answer				Marks	AO element	Guidance																							
21	(a)	<table border="1"> <thead> <tr> <th rowspan="2">Shell</th> <th rowspan="2">Total number of electrons</th> <th colspan="3">Sub-shell</th> </tr> <tr> <th>s</th> <th>p</th> <th>d</th> </tr> </thead> <tbody> <tr> <td>1st</td> <td>2</td> <td>2</td> <td></td> <td></td> </tr> <tr> <td>2nd</td> <td>8</td> <td>2</td> <td>6</td> <td></td> </tr> <tr> <td>3rd</td> <td>18</td> <td>2</td> <td>6</td> <td>10</td> </tr> </tbody> </table> <p>1st 2 rows correct → 1 mark ✓</p> <p>3rd row correct → 1 mark ✓</p>				Shell	Total number of electrons	Sub-shell			s	p	d	1st	2	2			2nd	8	2	6		3rd	18	2	6	10	2	AO1.1 ×2	<p><b>ALLOW</b></p> <p>(1)s<sup>2</sup></p> <p>(2)s<sup>2</sup> (2)p<sup>6</sup></p> <p>(3)s<sup>2</sup> (3)p<sup>6</sup> (3)d<sup>10</sup></p> <p><b>DO NOT ALLOW</b> extra numbers</p>
Shell	Total number of electrons	Sub-shell																													
		s	p	d																											
1st	2	2																													
2nd	8	2	6																												
3rd	18	2	6	10																											
	(b)	<table border="1"> <thead> <tr> <th></th> <th>Protons</th> <th>Neutrons</th> <th>Electrons</th> </tr> </thead> <tbody> <tr> <td><sup>76</sup>Se</td> <td>34</td> <td>42</td> <td>34</td> </tr> <tr> <td><sup>82</sup>Se</td> <td>34</td> <td>48</td> <td>34</td> </tr> </tbody> </table> <p><b>ALL</b> 6 entries correct for mark ✓</p>					Protons	Neutrons	Electrons	<sup>76</sup> Se	34	42	34	<sup>82</sup> Se	34	48	34	1	AO1.2												
	Protons	Neutrons	Electrons																												
<sup>76</sup> Se	34	42	34																												
<sup>82</sup> Se	34	48	34																												
	(c)	<p><b>FIRST CHECK ANSWER ON THE ANSWER LINE</b></p> <p><b>IF answer = 32.094 (to 3 DP) award 2 marks</b></p> $\frac{(32 \times 94.93) + (33 \times 0.78) + (34 \times 4.29)}{100}$ <p><b>OR</b> 32.0936 ✓</p> <p>= 32.094 (to 3 DP) ✓</p>				2	AO1.2 ×2	<p><b>For 1 mark: ALLOW ECF</b> → to 2 DP if:</p> <ul style="list-style-type: none"> <li>• %s used with wrong isotopes <b>ONCE</b></li> <li><b>OR</b></li> <li>• transposed decimal places for <b>ONE</b> %</li> </ul>																							

Question		Answer	Marks	AO element	Guidance
(d)	(i)		1	AO2.5	<b>ALLOW</b> any combination of skeletal <b>OR</b> structural <b>OR</b> displayed formula as long as unambiguous, e.g. CF <sub>3</sub> CHClBr
	(ii)	<p><b>FIRST, CHECK ANSWER</b>  <b>IF answer = 7.224 × 10<sup>22</sup>, award 2 marks</b></p> <hr/> $n(\text{C}_2\text{HBrClF}_3) = \frac{7.896}{197.4} \text{ OR } 0.04(00) \text{ (mol)} \checkmark$ $\text{F atoms} = 3 \times 0.0400 \times 6.02 \times 10^{23}$ $= 7.224 \times 10^{22} \checkmark$ <p>Minimum <b>3</b> SF required</p>	2	AO2.2 ×2	<p><b>Alternative approaches</b></p> $n(\text{F atoms}) = \frac{7.896}{197.4} \times 3 = 0.12 \checkmark$ $\text{F atoms} = 0.12 \times 6.02 \times 10^{23}$ $= 7.224 \times 10^{22} \checkmark$ <p><b>OR</b></p> <p>3 mol F atoms</p> $= 3 \times 6.02 \times 10^{23} = 1.806 \times 10^{24} \checkmark$ $\text{F atoms} = 1.806 \times 10^{24} \times 0.04$ $= 7.224 \times 10^{22} \checkmark$ <p><b>OR</b></p> <p>Mass F in 7.896 g</p> $= \frac{57}{197.4} \times 7.896 = 2.28 \text{ (g)} \checkmark$ $\text{F atoms} = \frac{2.28}{19} \times 6.02 \times 10^{23}$ $= 7.224 \times 10^{22} \checkmark$ <p><b>ALLOW ECF</b> from incorrect <math>n(\text{C}_2\text{HBrClF}_3)</math>  <b>ALLOW</b> use of <math>6.022 \times 10^{23}</math>  <b>OR</b> <math>6.023 \times 10^{23}</math></p> <hr/> <p><b>Common error</b>  <math>2.408 \times 10^{22}</math> <b>OR</b> <math>2.41 \times 10^{22} \rightarrow 1</math> mark  No × 3  <math>1.806 \times 10^{24} \rightarrow 1</math> mark No <math>n(\text{C}_2\text{HBrClF}_3)</math></p>
<b>Total</b>			<b>8</b>		

Question	Answer	Marks	AO element	Guidance
22 (a)	 <p><b>ΔH and products above reactants 1 mark</b>  <math>3\text{H}_2(\text{g}) + \text{CO}(\text{g})</math> on RHS <b>IGNORE</b> state symbols  <b>AND</b>  <math>\Delta H</math> labelled with product <b>above</b> reactant  <b>AND</b>  <math>\Delta H</math> arrow upwards ✓</p> <p><b><math>E_a</math> and <math>E_c</math> and curves 2 marks</b>  <b>ONE</b> curve shown with arrow labelled <math>E_a</math> <b>OR</b> <math>E_c</math> from reactants to top of curve  → 1 mark ✓</p> <p><b>TWO</b> curves shown with <math>E_c</math> arrow lower than <math>E_a</math>  <b>AND</b> each arrow from reactants to top of curve  → 2 marks ✓</p>	3	AO1.1 ×3	<p><b>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</b></p> <hr/> <p><b>IGNORE</b> state symbols.</p> <p><b>ΔH label</b>  <b>ALLOW</b> arrow even if it has a small gap at the top and bottom i.e. does not quite reach reactant or product line</p> <p><b><math>E_a</math> and <math>E_c</math> labels<sup>[SEP]</sup></b>  <b>ALLOW</b> no arrowhead(s) at both ends of activation energy line</p> <p><b>ALLOW</b> double headed arrows<sup>[SEP]</sup>  <b>BUT DO NOT ALLOW</b> arrowhead down</p> <p><math>E_a</math> and <math>E_c</math> lines must point to maximum (or near to the maximum) on the curve  <b>OR</b> span approximately 80% of the distance between reactants and maximum regardless of position</p>

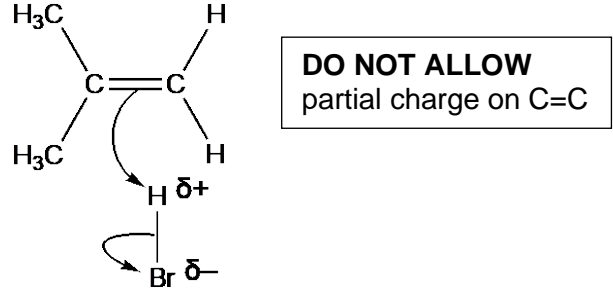
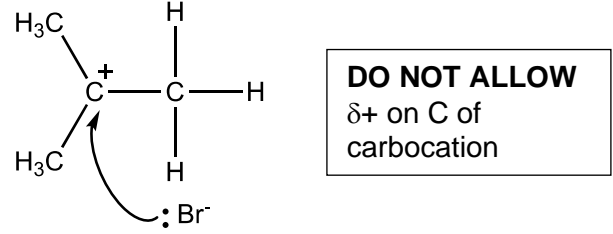
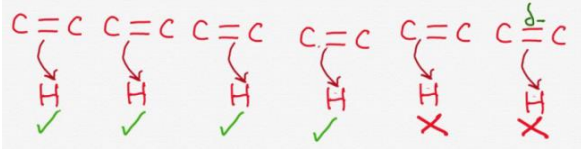
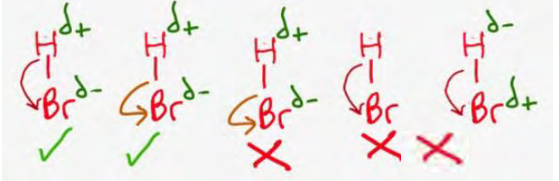
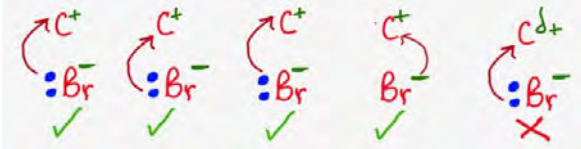


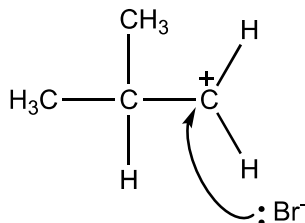
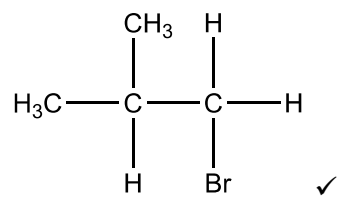
Question	Answer	Marks	AO element	Guidance
(b)	<p><b>Pressure:</b>  Right-hand side has more (gaseous) moles  <b>OR</b> 2 (gaseous) moles form 4 (gaseous) moles ✓    Low pressure <b>OR</b> decrease pressure ✓</p> <p><b>Temperature:</b>  (Forward) reaction is endothermic/<math>\Delta H</math> is positive  <b>OR</b> (Forward) reaction takes in heat ✓    High temperature <b>OR</b> increase temperature ✓</p>	4	 AO1.2 AO2.1    AO1.2 AO2.1	<p><b><i>FULL ANNOTATIONS MUST BE USED</i></b></p> <hr style="border-top: 1px dashed blue;"/> <p><b>ALLOW</b> suitable alternatives for right-hand side, e.g. towards H<sub>2</sub>/products <b>OR</b> forward direction  <b>OR</b> increases yield</p> <p>For moles, <b>ALLOW</b> molecules/particles</p> <p><b>ORA for</b> reverse reaction, e.g.  <b>ALLOW reverse</b> reaction is exothermic  /<math>\Delta H</math> is negative/gives out heat</p>

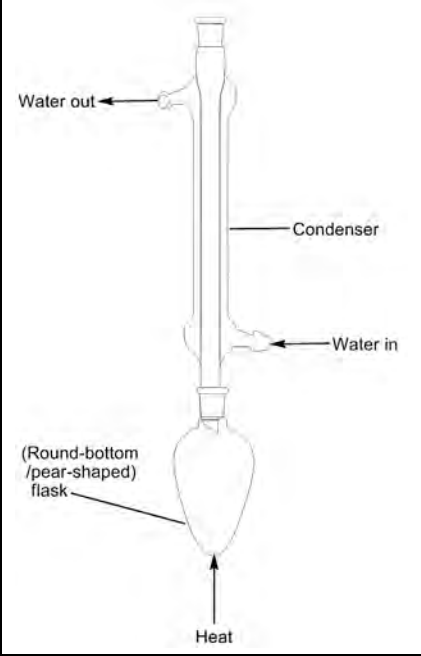
Question	Answer	Marks	AO element	Guidance
(c)	<p><b>FIRST, CHECK THE ANSWER ON ANSWER LINE IF bond enthalpy = (+)432 (kJ mol<sup>-1</sup>) award 3 marks</b></p> <hr/> <p><i>Energy for bonds broken ( 4 × C–H + 2 × O–H )</i>  <math>4 \times 413 + 2 \times 464</math>  <b>OR</b> 1652 + 928  <b>OR</b> 2580 (kJ) ✓</p> <p><i>H–H bond enthalpy correctly calculated</i>  <math>3 \times \text{H–H bond enthalpy} = 2580 - 1077 - 206</math>  <math>= 1297 \text{ (kJ mol}^{-1}\text{)} \checkmark</math></p> <p>H–H bond enthalpy = <math>\frac{1297}{3}</math>  <math>= (+)432/432.3\dots \text{ kJ mol}^{-1} \checkmark</math>  <i>Mark is for answer</i></p>	3	AO2.6 ×3	<p><b>FULL ANNOTATIONS MUST BE USED</b></p> <hr/> <p><b>IGNORE</b> sign</p> <p><b>IGNORE</b> sign</p> <p><b>ALLOW</b> ECF</p> <p><b>DO NOT ALLOW</b> – sign</p> <hr/> <p><b>COMMON ERRORS</b></p> <p><b>570/569.66</b> (Allow 6 or 7 at end) → 2 marks  <math>2580 - 1077 + 206 = \mathbf{1709} \checkmark</math>  <i>Wrong sign for 206</i>  Then 1709/3 = <b>570</b> ✓</p> <p><b>1150/1150.3...</b> → 2 marks  <math>2580 + 1077 - 206 = \mathbf{3451} \checkmark</math>  <i>Wrong sign for 1077</i>  3451/3 = <b>1150</b> ✓</p> <p><b>501</b> → 2 marks  <math>2580 - 1077 = \mathbf{1503} \checkmark</math>  <i>Missing 206</i>  1503/3 = <b>501</b> ✓</p>
	<b>Total</b>	<b>10</b>		

Question		Answer	Marks	AO element	Guidance
23	(a)	toxic/poisonous <b>OR</b> forms chlorinated hydrocarbons <b>OR</b> forms carcinogenic compounds / toxic compounds ✓	1	AO1.1	<b>IGNORE</b> 'harmful'/'dangerous'  <b>IGNORE</b> chlorine is carcinogenic/causes cancer dangerous for health/causes breathing problems
	(b)	Element <b>oxidised</b> : Chlorine/Cl Change from: -1 to 0 ✓  Element <b>reduced</b> : Manganese/Mn Change from +4 to +2 ✓	2	AO1.2 ×2	<b>MAX</b> 1 mark if no '+' sign for oxidation number  <b>ALLOW</b> Cl <sub>2</sub> for chlorine <b>ALLOW</b> 1-  <b>ALLOW</b> 4+ <b>AND</b> 2+  <b>ALLOW</b> 1 mark for all oxidation numbers correct, but oxidised and reduced the wrong way around  <b>IGNORE</b> numbers around equation i.e. treat as rough working
	(c)	$3KClO_4 + 8Al \rightarrow 3KCl + 4Al_2O_3$ ✓	1	AO2.6	<b>ALLOW</b> multiples

Question		Answer	Marks	AO element	Guidance
	(d)	<p><b>Plan</b> Mix (solution of) halogen and (solution of) halide ✓</p> <p><b>Observation with chlorine</b> bromide → orange/yellow ✓</p> <p><b>Observation with bromine</b> iodide → violet/purple/pink ✓</p> <p><b>Observation with iodine</b> No colour change/no reaction ✓</p> <p><b>Equation</b>  <math>Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-</math>  <b>OR</b>  <math>Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-</math>  <b>OR</b>  <math>Br_2 + 2I^- \rightarrow I_2 + 2Br^-</math> ✓</p> <p><b>Reactivity trend</b>  <math>Cl_2 &gt; Br_2 &gt; I_2</math> /decreases down the group ✓</p>	5 max	<p>AO3.3</p> <p>AO2.7</p> <p>AO2.7</p> <p>AO2.7</p> <p>AO2.6</p> <p>AO1.1</p>	<p><b>IGNORE</b> additions of halogen to same halide e.g. Chlorine to chloride.</p> <p><b>ALLOW</b> within text if it is clear that halogen is added to halide</p> <p>Check observations in a presented table.</p> <p><b>ALLOW</b> multiples, e.g. <math>\frac{1}{2}Cl_2 + Br^- \rightarrow \frac{1}{2}Br_2 + Cl^-</math></p>
		<b>Total</b>	<b>9</b>		

Question	Answer	Marks	AO element	Guidance
24 (a)	<p>Curly arrows can be straight, snake-like, etc. but <b>NOT</b> double headed or half headed arrows</p> <p><b>1. Curly arrow from C=C to HBr and H-Br</b> 2 marks</p>  <p>Curly arrow from C=C bond to H of H-Br ✓</p> <p>Correct dipole shown on H-Br <b>AND</b> curly arrow that breaks H-Br bond ✓</p> <p><b>2. Curly arrow from Br- to carbocation</b> 1 mark</p>  <p>Correct carbocation <b>AND</b> curly arrow from Br<sup>-</sup> to C<sup>+</sup> of <b>CORRECT</b> carbocation ✓</p> <p><b>3. Name of mechanism</b> 1 mark</p> <p>Electrophilic addition ✓</p>	4	AO1.2 AO1.2 AO2.5 AO1.1	<p><b>1st curly arrow must</b></p> <ul style="list-style-type: none"> <li>go to the H atom of H-Br <b>AND</b></li> <li>start from, <b>OR</b> be traced back to any point across width of C=C</li> </ul>  <p><b>2nd curly arrow must</b></p> <ul style="list-style-type: none"> <li>start from, <b>OR</b> be traced back to any part of <sup>δ+</sup>H-Br<sup>δ-</sup> bond <b>AND</b></li> <li>go to Br<sup>δ-</sup></li> </ul>  <p><b>3rd curly arrow must</b></p> <ul style="list-style-type: none"> <li>go to the C<sup>+</sup> of carbocation <b>AND</b></li> <li>start from, <b>OR</b> be traced back to any point across width of lone pair on :Br<sup>-</sup></li> <li><b>OR</b> start from - charge of Br<sup>-</sup> ion</li> </ul> 

Question		Answer	Marks	AO element	Guidance
					<p>(Lone pair <b>NOT</b> needed if curly arrow shown from – charge of Br<sup>-</sup> ion)</p> <p><b>IF</b> Br<sub>2</sub> is used instead of HBr contact your Team Leader</p> <p><b>DO NOT ALLOW</b> incorrect carbocation, i.e.</p> 
(b)	(i)	Same <b>molecular</b> formula <b>AND</b> Different <b>structural</b> formulae ✓	1	AO1.1	<p>Same formula is <b>not</b> sufficient (<i>no reference to molecular</i>)</p> <p>Different arrangement of atoms is <b>not</b> sufficient (<i>no reference to structure/structural</i>)</p> <p>For structural formulae, <b>ALLOW</b> structure/displayed/skeletal formulae</p>
(b)	(ii)		1	AO2.5	<b>ALLOW</b> any combination of skeletal <b>OR</b> structural <b>OR</b> displayed formula as long as unambiguous

Question		Answer	Marks	AO element	Guidance				
(c)	(i)	<table border="1"> <thead> <tr> <th>Alcohol C</th> <th>Reagent AND product</th> </tr> </thead> <tbody> <tr> <td> <math display="block">  \begin{array}{c}  \text{CH}_3 \quad \text{H} \\    \quad   \\  \text{H}_3\text{C}-\text{C}-\text{C}-\text{H} \\    \quad   \\  \text{OH} \quad \text{H} \quad \checkmark  \end{array}  </math> </td> <td>           NaOH AND NaBr  <b>OR</b>            KOH AND KBr  <b>OR</b>            OH<sup>-</sup> AND Br<sup>-</sup> ✓         </td> </tr> </tbody> </table>	Alcohol C	Reagent AND product	$  \begin{array}{c}  \text{CH}_3 \quad \text{H} \\    \quad   \\  \text{H}_3\text{C}-\text{C}-\text{C}-\text{H} \\    \quad   \\  \text{OH} \quad \text{H} \quad \checkmark  \end{array}  $	NaOH AND NaBr <b>OR</b> KOH AND KBr <b>OR</b> OH <sup>-</sup> AND Br <sup>-</sup> ✓	2	AO2.5 x2	<b>ALLOW</b> Reagent: H <sub>2</sub> O/water <b>AND</b> Product: HBr
Alcohol C	Reagent AND product								
$  \begin{array}{c}  \text{CH}_3 \quad \text{H} \\    \quad   \\  \text{H}_3\text{C}-\text{C}-\text{C}-\text{H} \\    \quad   \\  \text{OH} \quad \text{H} \quad \checkmark  \end{array}  $	NaOH AND NaBr <b>OR</b> KOH AND KBr <b>OR</b> OH <sup>-</sup> AND Br <sup>-</sup> ✓								
(c)	(ii)	 <p><b>1st mark:</b> Labelled condenser above a flask ✓</p> <p><b>2nd mark:</b> <i>Only available if 1st mark has been awarded</i></p> <p>Flask <b>AND</b> heat labelled ✓</p>	2	AO3.3 x2	<b>For condenser label,</b> <b>ALLOW</b> 'condenser' <b>OR</b> water in <b>AND</b> water out (May be implied by connection to tap and sink).				
<b>Total</b>			<b>10</b>						





Question	Answer	Marks	AO element	Guidance
26	<p><b>Mass spectrum:</b>  <math>M = 88</math> ✓</p> <p><b>IR:</b>            Peak at 1630-1820 (<math>\text{cm}^{-1}</math>) is C=O ✓              Peak at 2500–3500 (<math>\text{cm}^{-1}</math>) is O–H  <b>AND</b> carboxylic acid ✓</p> <p><b>Structures</b></p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <math display="block">\begin{array}{ccccccc} &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{O} \\ &amp;   &amp; &amp;   &amp; &amp;   &amp; &amp; // \\ \text{H} &amp; - \text{C} &amp; - &amp; \text{C} &amp; - &amp; \text{C} &amp; - &amp; \text{C} \\ &amp;   &amp; &amp;   &amp; &amp;   &amp; &amp; \backslash \\ &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; \text{OH} \end{array}</math> ✓           </div> <div style="text-align: center;"> <math display="block">\begin{array}{ccccccc} &amp; \text{H} &amp; &amp; \text{CH}_3 &amp; &amp; &amp; &amp; \text{O} \\ &amp;   &amp; &amp;   &amp; &amp; &amp; &amp; // \\ \text{H} &amp; - \text{C} &amp; - &amp; \text{C} &amp; - &amp; \text{C} &amp; - &amp; \text{C} \\ &amp;   &amp; &amp;   &amp; &amp; &amp; &amp; \backslash \\ &amp; \text{H} &amp; &amp; \text{H} &amp; &amp; &amp; &amp; \text{OH} \end{array}</math> ✓           </div> </div>	5	AO3.1 ×3     AO3.2 ×2	<p><b>ALLOW</b> stated values within stated ranges</p> <p><b>ALLOW</b> 'acid O–H</p> <p><b>IGNORE</b> references to C–O peaks</p> <p><b>ALLOW</b> any combination of skeletal <b>OR</b> structural <b>OR</b> displayed formula as long as unambiguous</p>
	<b>Total</b>	<b>13</b>		

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