

Organic Analysis
Answers

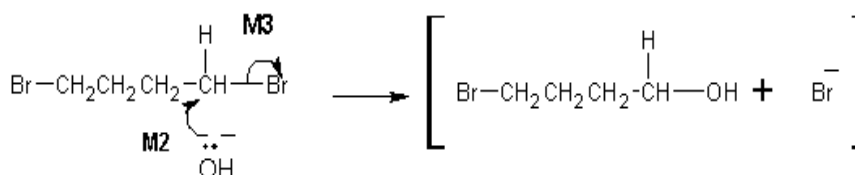
Q	Part	Sub Part	Marking Guidance	Mark	Comments
4	a		<p>The molecular ion is</p> <ul style="list-style-type: none"> The <u>molecule</u> with one / an electron knocked off / lost <p>OR</p> <ul style="list-style-type: none"> The <u>molecule</u> with a (single) positive charge <p>OR</p> <ul style="list-style-type: none"> the <u>ion</u> with / it has the largest / highest / biggest <u>m/z</u> (value / ratio) <p>OR</p> <ul style="list-style-type: none"> the <u>ion</u> with / it has an m/z equal to the M_r 	1	<p>Ignore the highest or biggest m/z <u>peak</u></p> <p>Ignore “the peak to the right”</p> <p>Ignore “compound”</p>
4	b	i	$2(14.00307) + 15.99491 = 44.00105$	1	A <u>sum</u> is needed to show this
4	b	ii	<p>Propane / C_3H_8 and carbon dioxide / CO_2 (and N_2O) or <u>they</u> or <u>both</u> the gases / molecules or <u>all three</u> gases / molecules have an (imprecise) M_r of 44.0 (OR 44)</p> <p>OR</p> <p>they have the <u>same</u> M_r <u>or</u> molecular mass (to one d.p)</p>	1	This could be shown in a calculation of relative masses for propane <u>and</u> carbon dioxide
4	b	iii	<p><u>By definition</u></p> <p>OR</p> <p>The <u>standard</u> / <u>reference</u> (value / isotope)</p>	1	<p>Ignore “element”</p> <p>Ignore “atom”</p>

6	b	i	M1 R is represented by Spectrum 2 M2 Spectrum 2 shows an infrared absorption / spike / dip / trough / peak with any value(s) / range within the range 1620 to 1680 (cm^{-1}) OR this range quoted / identified <u>and</u> this is due to <u>C=C</u> OR this information could be a correctly labelled absorption on the spectrum OR Spectrum 1 does not have an infrared absorption in range 1620 to 1680 (cm^{-1}) <u>and</u> does not contain <u>C=C</u> .	2	Award M1 if it is obvious that they are referring to the second spectrum (or the bottom one) M2 depends on a correct M1 Ignore other correctly labelled peaks Ignore reference to "double bond" or "alkene"
6	b	ii	<u>Functional group</u> (isomerism)	1	
6	b	iii	Cyclohexane OR Methylcyclopentane etc.	1	Named correctly Ignore structures and ignore numbers on the methyl group of methylcyclopentane

Question	Marking Guidance	Mark	Comments
6(a)(i)	<p><u>More absorption / less transmittance</u> of infrared radiation by it / water vapour</p> <p>OR <u>broader absorption</u> by OH</p> <p>OR <u>less absorption / more transmittance</u> of infrared radiation by carbon dioxide</p>	1	<p>Must be comparative</p> <p>This may be described and must not be contradictory</p> <p>Credit answers which refer correctly to “<u>transmittance</u>” (more absorption = less transmittance)</p>
6(a)(ii)	<p>M1 CO₂ contains C=O (stated like this or in words or strongly implied) OR is O=C=O</p> <p>M2 depends on correct M1</p> <p>OR expected absorption / peak (for C=O) is missing</p> <p>OR expected absorption / peak (for C=O) is shifted to 2300(cm⁻¹)</p> <p>OR asymmetric stretching is occurring (due to C=O)</p>	2	<p>If M1 and M2 not scored, give one mark for either</p> <p>No absorption / peak at 1700 (cm⁻¹) / 1715 (cm⁻¹)</p> <p>OR no absorption in the range 1680 – 1750 (cm⁻¹)</p> <p>Ignore “carbon-oxygen bonds”, “C-O bonds”</p> <p>Ignore reference to other absorptions</p> <p>For M2</p> <p>Allow “dip” OR “spike” OR “low transmittance” as alternatives for absorption.</p>
6(b)(i)	<p>An activity which has no <u>net / overall</u> (annual) <u>carbon emissions to the atmosphere / air</u></p> <p>OR An activity which has no <u>net / overall</u> (annual) <u>greenhouse gas emissions to the atmosphere / air</u>.</p> <p>OR There is no change in the <u>total amount of carbon dioxide / carbon / greenhouse gas present in the atmosphere / air</u></p>	1	<p>The idea that the <u>carbon / CO₂</u> given out equals the <u>carbon / CO₂</u> that was taken in <u>from the atmosphere / air</u></p> <p>Answer <u>must</u> refer to the atmosphere or air</p>
6(b)(ii)	$\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4 + 3\text{CO}_2 \longrightarrow 3\text{MgCO}_3 + 2\text{SiO}_2 + 2\text{H}_2\text{O}$	1	Allow multiples

Question	Marking Guidance	Mark	Comments
6(a)(i)	<p>M1 Initiation $\text{Cl}_2 \longrightarrow 2\text{Cl}\cdot$</p> <p>M2 First propagation $\text{Cl}\cdot + \text{CH}_2\text{Cl}_2 \longrightarrow \cdot\text{CHCl}_2 + \text{HCl}$</p> <p>M3 Second propagation $\text{Cl}_2 + \cdot\text{CHCl}_2 \longrightarrow \text{CHCl}_3 + \text{Cl}\cdot$</p>	3	Penalise absence of dot once only. Penalise + or – charges every time Accept dot anywhere on CHCl_2 radical but if the structure is drawn out, the dot must be on the carbon atom. Penalise this error once only Penalise once only for a line and two dots to show a bond. Penalise once only for double headed curly arrows Mark independently
6(a)(ii)	<p>M1 Condition ultra-violet / uv / sun light OR <u>high</u> temperature OR $400^\circ\text{C} \leq T \leq 900^\circ\text{C}$</p> <p>M2 Type of mechanism (free-) <u>radical substitution</u> (mechanism)</p>	2	
6(b)(i)	$\text{CHCl}_3 + \text{Cl}_2 \longrightarrow \text{CCl}_4 + \text{HCl}$	1	Allow X as alternative to CCl_4 only if X is clearly identified as CCl_4

<p>6(b)(ii)</p>	<p>M1 <u>Trichloromethane / CHCl₃ has a C–H bond</u></p> <p>OR</p> <p><u>X / CCl₄ / it has no C-H bond</u></p> <p>M2 The infrared spectrum shows (absorption / peak for C–H in range) <u>2850 to 3300</u> (cm⁻¹) <u>is missing</u></p>	<p>2</p>	<p>M1 must refer to presence or absence of the <u>C–H bond in a compound</u></p> <p>M2 answer must refer to / imply the spectrum Allow the words “dip” OR “spike” OR “low transmittance” as alternatives for absorption. Ignore references to other absorptions.</p>
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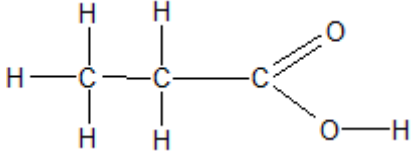
8(b)(i)	<p>M1 <u>nucleophilic substitution</u></p>  <p>M2 must show an arrow from the lone pair of electrons on the oxygen atom of the negatively charged hydroxide ion to the C atom.</p> <p>M3 must show the movement of a pair of electrons from the C—Br bond to the Br atom. Mark M3 independently provided it is from the <u>original molecule</u></p> <p>For M2 and M3 award full marks for an S_N1 mechanism</p> <p>NB The arrows here are double-headed</p>	3	<p>For M1, both words required</p> <p>Penalise M2 if covalent NaOH / KOH is used</p> <p>Penalise one mark from M2 or M3 if half-headed arrows are used</p> <p>Penalise M3 for formal charge on C of the C-Br or incorrect partial charges on C-Br</p> <p>Penalise once only for a line and two dots to show a bond.</p> <p>For M2 and M3, maximum 1 of 2 marks for the mechanism if wrong reactant is used.</p> <p>Penalise M3 if an extra arrow is drawn from the Br of the C-Br bond to, for example, K⁺</p> <p>Accept the correct use of “sticks”</p>
8(b)(ii)	<p>M1 B</p> <p>M2 C</p> <p>M3 A</p>	3	

Question	Marking Guidance	Mark	Comments
6(a)	<p>For 2 marks at least <u>one correct reference either to M_r or value to 5 decimal places</u> required</p> <p>M1 Compounds <u>1 and 3</u> (butanal and butanone) have the same M_r (to 5dp) <u>because either</u></p> <ul style="list-style-type: none"> • they contain the <u>same</u> number of atoms of the same / each element • are <u>both</u> C_4H_8O • have the <u>same molecular formula</u> • contain the <u>same number</u> of C,H and O atoms <p>M2 Compound <u>2</u> (pentane) has a different M_r (to 5dp) <u>because either</u></p> <ul style="list-style-type: none"> • it has <u>different</u> numbers of atoms of different elements • is C_5H_{12} / <u>only contains</u> C and H • <u>different molecular formula</u> • does not contain oxygen (atom) / C=O 	2	<p>QoL (associated with the bold statement here)</p> <p>It may be possible to award 2 marks if there is a clear statement about oxygen having a different precise A_r in the context of the comparison</p> <p>NB The word “similar” does not mean “the same”</p>

6(b)	<p>With Tollens' (reagent) M1 <u>silver mirror</u> OR <u>black solid/precipitate</u> (NOT silver (mirror) precipitate) M2 (stays) colourless OR no change / no reaction OR no silver mirror</p>	<p>With Fehling's (solution) M1 <u>Red solid/precipitate</u> (Credit orange or brown <u>solid</u>) M2 (stays) blue OR no change / no reaction OR no red solid OR no (red) precipitate</p>	2	<p><u>N.B No mark is awarded for the reagent</u> If no reagent given allow 1 mark for a consistent statement of M1 and M2 For M2, ignore "nothing (happens)" And ignore "no observation"</p>
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Question	Marking Guidance	Mark	Comments
10(a)(i)	C	1	
10(a)(ii)	A	1	
10(a)(iii)	D	1	
10(a)(iv)	B	1	
10(b)	<p>M1 Br₂ OR bromine (water) OR bromine (in CCl₄ / organic solvent)</p> <p>Either order</p> <p>M2 <u>cyclohexane</u> OR A or the alkane: remains orange / red / yellow / brown / the same OR no reaction OR reference to colour going to cyclohexane layer</p> <p>M3 <u>cyclohexene</u> OR D or the alkene: decolourised / goes colourless / loses its colour</p> <p>Alternatives : potassium manganate(VII)</p> <p>M1 KMnO₄ in acid M2 purple M3 colourless</p> <p>M1 KMnO₄ in alkali / neutral M2 purple M3 brown solid</p> <p>Give appropriate credit for the use of iodine and observations</p>	3	<p>If M1, has no reagent or an incorrect reagent, CE=0</p> <p>Ignore “acidified”</p> <p>For M1 penalise Br (or incorrect formula of other correct reagent), but mark on</p> <p>For M1, it must be a whole reagent and/or correct formulae</p> <p>If oxidation state given in name, it must be correct.</p> <p>For M2 credit “no change”</p> <p>Ignore “nothing”</p> <p>Ignore “nothing happens”</p> <p>Ignore “no observation”</p> <p>For M3, ignore “goes clear”</p> <p>No credit for combustion observations</p>

10(c)	<p>M1 <u>acidified potassium or sodium dichromate</u> OR eg $\text{H}_2\text{SO}_4 / \text{K}_2\text{Cr}_2\text{O}_7$ OR $\text{H}^+ / \text{K}_2\text{Cr}_2\text{O}_7$ OR correct combination of formula and name M2 oxidation OR oxidised OR redox M3 secondary / 2° (alcohol)</p>	3	<p>For M1, it must be a whole reagent and/or correct formulae If oxidation state given in name, it must be correct. Do not penalise incorrect attempt at formula if name is correct or <i>vice versa</i> Credit acidified potassium chromate(VI) / $\text{H}_2\text{SO}_4 + \text{K}_2\text{CrO}_4$</p>
10(d)	<p>M1 (free-) <u>radical substitution</u> (mechanism) M2 $\text{Br}_2 \longrightarrow 2\text{Br}\cdot$ M3 $\text{Br}\cdot + \text{CH}_4 \longrightarrow \cdot\text{CH}_3 + \text{HBr}$ M4 $\text{Br}_2 + \cdot\text{CH}_3 \longrightarrow \text{CH}_3\text{Br} + \text{Br}\cdot$</p> <p>M5 Condition ultra-violet / uv / sun light OR <u>high</u> temperature OR $125\text{ }^\circ\text{C} \leq T \leq 600\text{ }^\circ\text{C}$ OR $400\text{ K} \leq T \leq 870\text{ K}$</p>	5	<p>M1 both words required Penalise absence of dot once only. Penalise + or – charges every time Accept dot anywhere on methyl radical Accept a <u>correct</u> termination step for 1 mark if neither M3 nor M4 are scored; otherwise ignore termination steps Mark independently NB If Cl_2 is used, penalise every time (this may be for M2,M3 and M4) If cyclohexane is used, penalise every time (this may be for M3 and M4) For M5 ignore “heat”</p>

Question	Marking Guidance	Mark	Comments
6(a)(i)	C_4H_{10} $M_r = 4(12.00000) + 10(1.00794)$ $= \underline{58.07940}$ or $\underline{58.0794}$ or $\underline{58.079}$ or $\underline{58.08}$ and <u>58.1</u>	1	Working is essential, leading to the final value of 58.1 which must be stated in addition to one of the four numbers underlined
6(a)(ii)	<u>By definition</u> OR The <u>standard</u> / <u>reference</u> (value / isotope)	1	Reference to ^{12}C alone is not enough
6(b)		1	All bonds and atoms must be drawn Give credit for the displayed formula for the anion
6(c)(i)	$H_2C=CHCH_2OH$	1	Any correct representation including correct use of “sticks”. Require the double bond to be shown

6(c)(ii)	<u>Addition</u> (polymerisation)	1	ONLY this answer
6(c)(iii)	M1 <u>C=C</u> (in range) 1620 to 1680 (cm ⁻¹) M2 <u>O—H</u> (in range) 3230 to 3550 (cm ⁻¹)	2	Award one mark for two correct ranges but a failure to draw out the C=C or O—H bonds
6(d)(i)	CH ₃ COCH ₃	1	Any correct representation including correct use of “sticks”
6(d)(ii)	C	1	