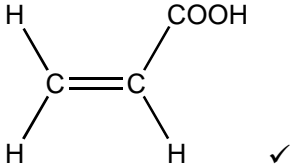
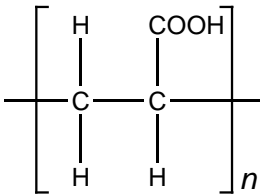
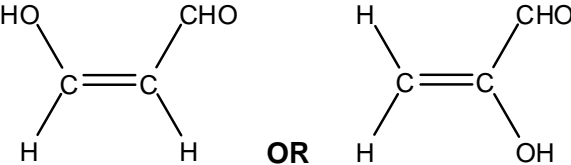
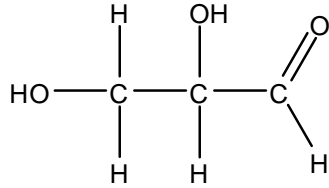
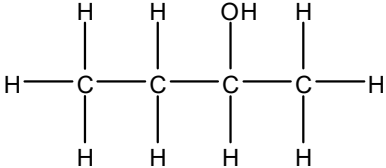
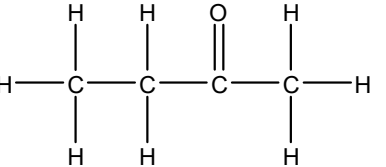
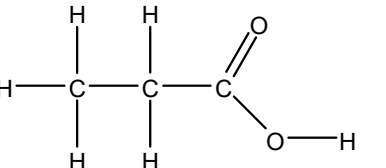
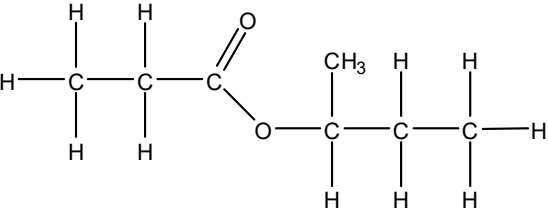
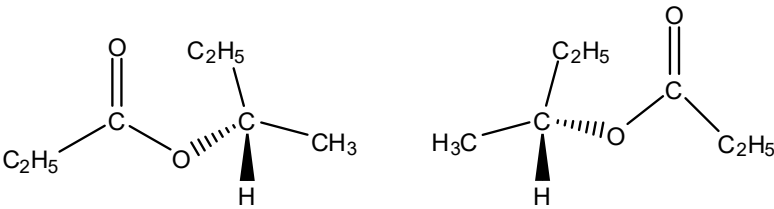


Question		Answer	Mark	Guidance
1	(a)	<p>Mole ratio C : H : O is 3.33 : 6.67 : 3.33 ✓</p> <p>Empirical formula is CH₂O ✓</p> <p>Molecular formula is C₃H₆O₃ AND use of 90 OR 3 × 30 ✓</p>	3	<p>ALLOW $\frac{40.00}{12.0} : \frac{6.67}{1.0} : \frac{53.33}{16.0}$</p> <p>ALLOW mass of C = 0.400 × 90 or 36 AND mass of H = 0.06677 × 90 or 6 AND mass of O = 0.5333 × 90 or 48</p>

Question	Answer	Mark	Guidance
(b)	<p>Evidence of carboxylic acid (1 mark) IR: 1550–1800 cm⁻¹ AND C=O/carbonyl AND 2300–3700 cm⁻¹ AND O–H in carboxylic acid ✓</p> <p>Evidence of alcohol (1 mark)</p> <p>(broad) 3200–3700 cm⁻¹ linked to O–H in alcohol OR (is a primary) alcohol as oxidised (to a COOH) OR is an alcohol as it forms a carboxylic acid OR is an alcohol as water is eliminated. ✓</p> <p>Identifications (2 marks)</p> <p>L:</p> $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{HO}-\text{C}-\text{C}-\text{COOH} \\ \quad \\ \text{H} \quad \text{H} \end{array} \quad \checkmark$ <p>M:</p> $\begin{array}{c} \text{H} \\ \\ \text{HOOC}-\text{C}-\text{COOH} \\ \\ \text{H} \end{array} \quad \checkmark$ <p>Equation (1 mark)</p> $\text{C}_3\text{H}_6\text{O}_3 + 2[\text{O}] \longrightarrow \text{C}_3\text{H}_4\text{O}_4 + \text{H}_2\text{O} \quad \checkmark$	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>LOOK ON THE SPECTRUM for labelled peaks which can be given credit</p> <p>ALLOW ranges from <i>Data Sheet</i>. C=O within range 1640–1750 cm⁻¹; (broad) O–H within range 2500–3300 cm⁻¹ (broad) O–H within range 3200–3550 cm⁻¹</p> <p>For ALL structures: ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above</p> <p>IGNORE names</p> <p>-----</p> <p>FOR M: ALLOW 1 mark for $\text{HOOC}-\overset{\text{O}}{\parallel}{\text{C}}-\text{COOH} \quad \checkmark$</p> <p>AS ECF from L as either</p> $\begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ \quad \quad \\ \text{HO}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array} \quad \text{OR} \quad \begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ \text{HO}-\text{C}-\text{C}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$ <p>Equation: $\text{C}_3\text{H}_6\text{O}_3 + 4[\text{O}] \longrightarrow \text{C}_3\text{H}_2\text{O}_5 + 2\text{H}_2\text{O} \quad \checkmark$</p> <p>-----</p> <p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above in equation</p>

Question	Answer	Mark	Guidance
(c)	<p>Monomer N: _____ (1 mark)</p>  <p>Polymer P: _____ (1 mark)</p> <p>Section showing at least one repeat unit of a polymer formed from N with side links ✓ e.g.</p> 	4	<p>For ALL structures: ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above</p> <p>IGNORE names</p> <p>ALLOW 1 mark for either</p>  <p>AS ECF from L:</p>  <hr style="border-top: 1px dashed black;"/> <p>For P: ALLOW ECF from an alkene with molecular formula $C_3H_4O_2$</p> <p>ALLOW one or more repeat units but has to have a whole number of repeat units</p> <p>ALLOW repeat unit with no brackets and absence of n</p>

Question	Answer	Mark	Guidance
	<p>Repeat units (1 mark)</p> <p>$n = 10000/72 = 139 \checkmark$</p> <p>Equation (1 mark)</p> <p>Balanced equation for formation of P from N ✓ e.</p> $n \begin{array}{c} \text{H} & & \text{COOH} \\ & \diagdown & / \\ & \text{C} = \text{C} & \\ & / & \diagdown \\ \text{H} & & \text{H} \end{array} \longrightarrow \left[\begin{array}{cc} \text{H} & \text{COOH} \\ & \\ -\text{C} & - & \text{C}- \\ & \\ \text{H} & \text{H} \end{array} \right]_n$		<p>MUST be a whole number. ALLOW 138 OR 140</p> <hr/> <p>For equation, ALLOW molecular OR structural OR skeletal OR displayed formulae OR mixture of the above e.g. ALLOW $n\text{C}_3\text{H}_4\text{O}_2 \longrightarrow (\text{C}_3\text{H}_4\text{O}_2)_n$</p> <p>$n$ on LHS can be at any height to the left of formula AND n on the RHS must be a subscript (essentially below the side link if displayed/skeletal formula is used)</p> <p>ALLOW use of calculated value for n in equation e.g. $139\text{C}_3\text{H}_4\text{O}_2 \longrightarrow (\text{C}_3\text{H}_4\text{O}_2)_{139}$</p>
	Total	12	

Question	Answer	Mark	Guidance
2 (a)	<p>Molar mass of B = 74 ✓</p> <p>B-F clearly identified</p> <p>B/alcohol:</p>  <p style="text-align: right;">✓</p> <p>C/ketone:</p>  <p style="text-align: right;">✓</p> <p>D/carboxylic acid:</p>  <p style="text-align: right;">✓</p> <p>E and F:</p>  <p style="text-align: right;">✓</p> <p>H₂O/water ✓</p>	6	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Check and annotate page 19 below this response</p> <p>Molar mass = $\frac{2.59}{0.035} = 74$</p> <p>For structure of B, C, D or E/F ALLOW correct displayed OR correct structural formula OR correct skeletal formula OR mixture of the above as long as unambiguous.</p> <p>DO NOT ALLOW missing H atom(s) in a displayed formula for one structure but ALLOW missing H atoms in subsequent structures.</p> <p>IGNORE names of organic compounds</p> <p>E and F can be identified either way round</p> <p>ALLOW H₂O or displayed formula for mark</p> <p>For E and F – ALLOW the two optical isomers</p> 

Question	Answer	Mark	Guidance
(b)	<p><u>Molecular formula for G:</u> 2 marks</p> <p>Mole ratio C : H : O = $\frac{55.8}{12.0} : \frac{7.0}{1.0} : \frac{37.2}{16.0}$</p> <p>OR 4.65 : 7.0 : 2.33/2.325 OR 2 : 3 : 1 OR C₂H₃O ✓</p> <p>Molecular formula of G C₄H₆O₂ ✓</p> <p><u>Mass spectrum for G:</u> 2 marks</p> <p>Peak X or peak 41 indicates C₃H₅⁺ ✓</p> <p>Peak Y or peak 45 indicates COOH⁺ ✓</p> <p><u>Infrared for G:</u> 1 mark</p> <p>Peak at 1640–1750 cm⁻¹ indicates presence of C=O AND Peak at 2500–3300 cm⁻¹ (indicates the presence of) –OH group linked carboxylic acid/COOH QWC ✓</p>	7	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>ALLOW mass of C = 0.558 x 86 or 48 AND mass of H = 0.07 x 86 or 6 AND mass of O = 0.372 x 86 = 32</p> <p>+ charge required for each response ALLOW one mark if both formulae are correct but with no charge/incorrect charge</p> <p>ALLOW any possible fragments that contain C, H and/or O that have the correct mass. E.g. Peak X indicates C₂OH⁺, Peak Y indicates C₂H₅O⁺ Unfeasible fragments are not allowed e.g. C₃H₉⁺ (too many H atoms)</p> <p>LOOK ON THE SPECTRUM for labelled absorbance which can be given credit Candidates must link absorbance to bond in order to gain the mark</p> <p>ALLOW 1700 cm⁻¹</p> <p>For 2500–3300 cm⁻¹, ALLOW 2900 cm⁻¹ or any stated wavenumber with range 2500–3300 cm⁻¹ ALLOW wavenumber range up to 2400–3500 cm⁻¹</p>

Question	Answer	Mark	Guidance
	<p><u>Structure of G:</u> <u>2 marks</u></p> <p>Correct structure:</p> <p>1 mark for one of the following structures of C₄H₆O₂:</p> <p>H₂C=CH—CH₂—COOH OR H₃C—CH=CH—COOH OR</p>		<p>ALLOW structural, skeletal or displayed formula.</p> <p>DO NOT ALLOW ECF from incorrect molecular formula</p>
	Total	13	

Question			Answer	Marks	Guidance
3	(a)	(i)	256 ✓	1	
		(ii)	S ₈ ✓	1	ALLOW ³² S ₈ OR ³² ₁₆ S ₈ DO NOT ALLOW ³³ S ₈ OR ³⁰ ₁₆ S ₈ etc
		(iii)	S ₄ ⁺ ✓	1	Positive ion must be present ALLOW ³² S ₄ ⁺ OR ³² ₁₆ S ₄ ⁺ DO NOT ALLOW ³³ S ₄ ⁺ OR ³⁰ ₁₆ S ₄ ⁺ etc
	(b)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 195.2, award 2 marks . IF answer = 195.16 award 1 marks . = $\frac{(194 \times 33) + (195 \times 34) + (196 \times 25) + (198 \times 8)}{100}$ ✓ 195.2 ✓	2	195 on its own with no working scores 0 marks
	(c)		Monitor air pollution OR breathalysers ✓	1	ALLOW measure the concentration or abundance of atmospheric pollutants ALLOW measure concentration of named atmospheric pollutant ALLOW monitoring of gases in car exhaust fumes ALLOW drug detection or drug identification IGNORE night vision goggles, identifying gases on distant planets / ice samples

Question	Answer	Marks	Guidance
(d)	<p>mole ratio C : H : O $\frac{66.7}{12.0} : \frac{11.1}{1.0} : \frac{22.2}{16.0}$ OR 5.56 : 11.1 : 1.39 ✓</p> <p>4 : 8 : 1 OR C₄H₈O ✓</p> <p>contains a C=O or carbonyl because of absorbance at about 1710 cm⁻¹ ✓</p> <p>Any two from:</p> $\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{C} - \text{H} \\ \qquad \qquad \qquad \qquad \qquad \parallel \\ \qquad \qquad \qquad \qquad \qquad \text{O} \end{array}$ $\begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{CH} - \text{C} - \text{H} \\ \qquad \qquad \qquad \qquad \parallel \\ \qquad \qquad \qquad \qquad \text{O} \end{array}$ $\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{C} - \text{CH}_3 \\ \qquad \qquad \qquad \qquad \parallel \\ \qquad \qquad \qquad \qquad \text{O} \end{array} \quad \checkmark\checkmark$	5	<p>PLEASE LOOK AT THE SPECTRA AND ABOVE THE SPECTRA FOR POSSIBLE ANSWERS</p> <p>ALLOW two marks for 72 x 66.7/100 = 48/12 = 4 (C) 72 x 11.1/100 = 8 = 8 (H) 72 x 22.2/100 = 16 = 1 (O)</p> <p>ALLOW C=O or carbonyl since has absorbance within the range 1640 to 1750 cm⁻¹ ALLOW ketone OR aldehyde linked to correct absorbance ALLOW 'could be aldehyde, ketone, carboxylic acid, ester (or amide) because of absorbance between range 1640 to 1750 cm⁻¹' (ie direct quote from the data book) DO NOT ALLOW reference to M being a carboxylic acid, ester or amide unless they are included in a list with aldehyde/ketone in which case IGNORE carboxylic acid/ester/amide IGNORE reference to C—O / absence of O—H DO NOT ALLOW has O—H</p> <p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) eg CH₃CH₂CH₂CHO, CH₃COCH₂CH₃ OR (CH₃)₂CHCHO</p> <p>DO NOT ALLOW C₃H₇CHO IGNORE incorrect name correct name on its own is not sufficient</p>
	Total	11	

Question	Answer	Mark	Guidance
4	<p>ANY SEVEN FROM:</p> <p>Compound X QWC: X contains C=O because of absorption at 1720 cm⁻¹ AND contains O–H because of (broad) absorption between 2500 to 3300 cm⁻¹ ✓</p> <p>So X is a carboxylic acid ✓</p> <p>Molar ratio (C:H:O) of X is 4.05 : 8.1 : 2.7 OR $\frac{48.65}{12.0} : \frac{8.11}{1.0} : \frac{43.24}{16.0}$ ✓ (Empirical formula) is C₃H₆O₂ ✓</p> <p>M_r is 74.0 so X is C₃H₆O₂ ✓</p>	7	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES</p> <p>PLEASE ENSURE YOU LOOK AT THE DATA AND SPECTRA ON PAGE 20 IN CASE THEY INCLUDE COMMENTS THAT ARE WORTHY OF CREDIT. MARK THIS PAGE WITH AN OMISSION MARK, ^ , IF BLANK</p> <p>QWC: mark is integrated into the chemistry marks. These marks need to link evidence with an explanation</p> <p>ALLOW X contains C=O and O–H because of absorptions at 1720 cm⁻¹ and 2500 to 3300 cm⁻¹</p> <p>ALLOW X contains carboxylic acid/COOH because of absorption at 1720 cm⁻¹ and (broad) absorption between 2500 to 3300 cm⁻¹ ✓✓</p> <p>ALLOW alternative approach to molecular formula</p> <p>M_r is 74.0 ✓ $74 \times \frac{48.65}{100} : 74 \times \frac{8.11}{100} : 74 \times \frac{43.24}{100} = 36 : 6 : 32$ ✓ C₃H₆O₂ ✓</p> <p>This mark is for some evidence of using M_r to deduce the molecular or structural formula ALLOW M_r is 74.0 so X is CH₃CH₂COOH ✓ DO NOT ALLOW ECF from the empirical formula with the wrong molar ratio</p>

Question	Answer	Mark	Guidance
	<p>Compound Y</p> <p>QWC Y contains O–H because of absorption between 3100 and 3500 cm^{-1} ✓</p> <p>QWC Mass spec of Y has molecular ion, $m/z = 46$ so M_r is 46 ✓</p> <p>Correct identification of one fragment from a m/z value e.g. $m/z = 31$ is CH_2OH^+; $m/z = 29$ is C_2H_5^+; $m/z = 15$ is CH_3^+ ✓</p>		<p>ANNOTATE ANSWER WITH TICKS AND CROSSES</p> <p>ALLOW Y is an alcohol (or phenol) because of absorption between 3200 and 3550 cm^{-1}</p> <p>ALLOW Y contains C–O, C–H and O–H bonds because of absorptions at approximately 1030, 2950 and 3350 cm^{-1}</p> <p>ALLOW $m/z = 46$ so M_r is 46</p> <p>OR mass spectrum has a peak at 46 which is the M_r</p> <p>OR M_r is 46 because of m/z peak shown on the actual spectra</p> <p>$M_r = 46$ on its own is not sufficient</p> <p>$m/z = 46$ on its own is not sufficient</p> <p>ALLOW $m/z = 31$ shows CH_2OH (fragment);</p> <p>$m/z = 29$ shows C_2H_5 (fragment);</p> <p>$m/z = 15$ is CH_3 (fragment)</p>
	<p>Identification of compounds</p> <p>So X must be $\text{CH}_3\text{CH}_2\text{COOH}$ OR propanoic acid ✓</p> <p>So Y is ethanol OR $\text{C}_2\text{H}_5\text{OH}$ OR $\text{CH}_3\text{CH}_2\text{OH}$ ✓</p> <p>Z is $\text{CH}_3\text{CH}_2\text{COOC}_2\text{H}_5$ OR ethyl propanoate ✓</p>	3	<p>Note: an incorrect name CONs a correct structure</p> <p>ALLOW skeletal OR displayed formula throughout</p> <p>DO NOT ALLOW propanoic acid with wrong structure or incorrect molecular formula</p> <p>DO NOT ALLOW ethanol with wrong structure or incorrect molecular formula</p> <p>DO NOT ALLOW ethyl propanoate with wrong structure or incorrect molecular formula</p> <p>ALLOW ECF for identification of Z from incorrect X and Y.</p> <p>DO NOT ALLOW this ECF if name and structures of X or Y do not match</p>
	Total	10	

Question			Expected Answers	Marks	Additional Guidance
5	a	i	Any two from: Any value between 1000–1300 ✓ Any value between 2850–3100 ✓ Any value between 3200–3550 ✓	2	
		ii	Orange to green or blue ✓	1	
		iii	$\text{CH}_3\text{CH}_2\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}$ OR $\text{CH}_3\text{CH}_2\text{OH} + 2[\text{O}] \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$ Correct organic product ✓ Balanced equation ✓	2	IGNORE any state symbols ALLOW CH_3COH in equation but not for the structure ALLOW equations with molecular formulae but not the product mark
	b	i	Absorption around 2850–3100 (cm^{-1}) so contains C—H bonds ✓ No other important absorptions present / no other characteristic absorptions ✓	2	Answer must have a reference to infrared spectrum i.e. use of cm^{-1} or data from the infrared spectrum ‘Has no other peaks so no functional groups present’ is not sufficient BUT There are no peaks due to functional groups is sufficient ALLOW peaks instead of absorption ALLOW no absorption due to C=O and O—H / no absorption due to carbonyl and hydroxyl
		ii	Peak furthest to right hand side is 58 / molecular ion peak is 58 / peak at highest mass ✓	1	ALLOW peak at m/z 58 marked on the mass spectrum / M peak is 58 / peak at 58 linked to the molecular mass DO NOT ALLOW highest peak but ALLOW 58 is the highest peak

Question		Expected Answers	Marks	Additional Guidance
b	iii	$ \begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} \quad \begin{array}{ccc} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array} $ <p>BOTH isomers correct ✓</p>	1	<p>If three structures are drawn then do not award mark</p> <p>ALLOW skeletal formulae / structural formulae</p> <p>IGNORE incorrect names</p>
	iv	CH_3^+ ✓ C_2H_5^+ ✓ C_3H_7^+ / $\text{CH}_3\text{CH}_2\text{CH}_2^+$ / $(\text{CH}_3)_2\text{CH}^+$ ✓	3	<p>Essentially marks are allocated as positive ions ✓</p> <p>Formula of two fragments correct (ignore charge) ✓</p> <p>BUT</p> <p>formulae of all three fragments correct (ignore charge) ✓✓</p>
	v	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ because there is a peak at $m/z = 29$ ✓	1	<p>ALLOW name, displayed or skeletal structure</p> <p>ALLOW butane because there is a C_2H_5 fragment</p> <p>ALLOW butane because it gives all three fragments listed in (iv)</p>
Total			13	