

4(a)(i)	reduction
4(a)(ii)	$\text{PCl}_5 / \text{PCl}_3 / \text{SOCl}_2$ OR KCl / NaCl AND conc. H_2SO_4 / conc. H_3PO_4
4(a)(ii)	M1 $\text{C}_2\text{H}_5\text{CH}_2\text{Cl} + \text{NaOH} \rightarrow \text{C}_3\text{H}_6 + \text{H}_2\text{O} + \text{NaCl}$ M2 ethanol (solvent) AND heat / reflux
4(a)(iv)	conc. H_2SO_4 OR conc. H_3PO_4 OR Al_2O_3 AND heat
4(b)(i)	addition
4(b)(ii)	M1 (molecules that have the) same structural formula (and same molecular formula) M2 but different 3D / spatial arrangement of atoms / groups
4(b)(iii)	$\begin{array}{cccc} \text{H} & \text{CH}_3 & \text{H} & \text{CH}_3 \\ & & & \\ \text{---C---} & \text{C---} & \text{C---} & \text{C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ M1 M2 optical isomerism M3 the methylated carbon has four different groups attached
4(b)(iv)	M1 non-biodegradability M2 harmful combustion products
4(c)(i)	2,3-dimethylbut-1-ene
4(c)(ii)	(The spectrum is of) X AND 41 is $[\text{CH}_2=\text{CCH}_3]^+$ / 41 is C_3H_5^+ OR 43 is $[\text{CH}_3\text{CHCH}_3]^+$ / 43 is C_3H_7^+ OR X would NOT have significant peak at 54 / $[(\text{CH}_3)_2\text{C}=\text{C}^+]$ / C_4H_6^+ OR X would NOT have significant peak at 42 due to $[(\text{CH}_3)_2\text{C}^+]$ / C_3H_6^+
4(c)(iii)	$([\text{M}+1]^+ / 34.7 \times 100 / 1.1 = 6)$ $[\text{M}+1]^+ = 2.29$

4(a)(i)	free-radical substitution
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4(a)(ii)	M1 $\text{C}_3\text{H}_8 + \text{Cl}\cdot \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\cdot + \text{HCl}$ OR $\text{C}_3\text{H}_8 + \text{Cl}\cdot \rightarrow \text{C}_3\text{H}_7\cdot + \text{HCl}$ M2 $\text{CH}_3\text{CH}_2\text{CH}_2\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Cl} + \text{Cl}\cdot$ OR $\text{C}_3\text{H}_7\cdot + \text{Cl}_2 \rightarrow \text{C}_3\text{H}_7\text{Cl} + \text{Cl}\cdot$ etc M3 $\text{CH}_3\text{CH}_2\text{CH}_2\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ OR $\text{C}_3\text{H}_7\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$
4(a)(iii)	homolytic
4(a)(iv)	1,2-dichloropropane
4(a)(v)	M1 (type of structural isomerism) positional M2 (type of stereoisomerism) optical
4(b)	sodium hydroxide AND water
4(c)(i)	orange to green
4(c)(ii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + 2[\text{O}] \rightarrow \text{CH}_3\text{CH}_2\text{COOH} + \text{H}_2\text{O}$
4(d)(i)	condensation
4(d)(ii)	M1 absorption labelled at approx. 1750 cm^{-1} identified as C=O M2 absorption labelled at approx. 1650 cm^{-1} identified as C=C M3 absorption labelled at approx. 1170 cm^{-1} identified as C—O
4(d)(iii)	$(0.31 / 4.7 \times 100 / 1.1) = 6$ carbon atoms