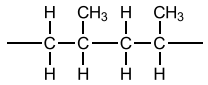
4(a)(i)	reduction
4(a)(ii)	PCl_5 / PCl_3 / $SOCl_2$ **OR** KCl / NaCl **AND** conc. H_2SO_4 / conc.H_3PO_4
4(a)(ii)	**M1** $C_2H_5CH_2Cl + NaOH \rightarrow C_3H_6 + H_2O + NaCl$ **M2** ethanol (solvent) **AND** heat / reflux
4(a)(iv)	conc. H_2SO_4 **OR** conc. H_3PO_4 **OR** Al_2O_3 **AND** heat
4(b)(i)	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)	 **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 $[CH_2{=}CCH_3]^+$ / 41 is $C_3H_5^+$ **OR** 43 is $[CH_3CHCH_3]^+$ / 43 is $C_3H_7^+$ **OR X** would NOT have significant peak at 54 / $[(CH_3)_2C{=}C^+]$ / $C_4H_6^+$ **OR X** would NOT have significant peak at 42 due to $[(CH_3)_2C^+]$ / $C_3H_6^+$
4(c)(iii)	($[M+1]^+$ / 34.7 × 100 / 1.1 = 6) $[M+1]^+ = 2.29$

4(a)(i)	free-radical substitution

4(a)(ii)	**M1** $C_3H_8 + Cl^\bullet \rightarrow CH_3CH_2CH_2^\bullet + HCl$ **OR** $C_3H_8 + Cl^\bullet \rightarrow C_3H_7^\bullet + HCl$ **M2** $CH_3CH_2CH_2^\bullet + Cl_2 \rightarrow CH_3CH_2CH_2Cl + Cl^\bullet$ **OR** $C_3H_7^\bullet + Cl_2 \rightarrow C_3H_7Cl + Cl^\bullet$ etc **M3** $CH_3CH_2CH_2^\bullet + Cl^\bullet \rightarrow CH_3CH_2CH_2Cl$ **OR** $C_3H_7^\bullet + Cl^\bullet \rightarrow CH_3CH_2CH_2Cl$
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)	$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$
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 × 100 / 1.1) = 6 carbon atoms