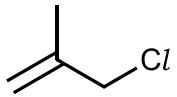
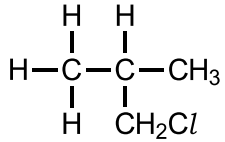
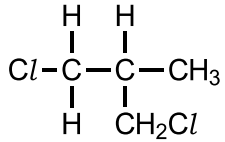
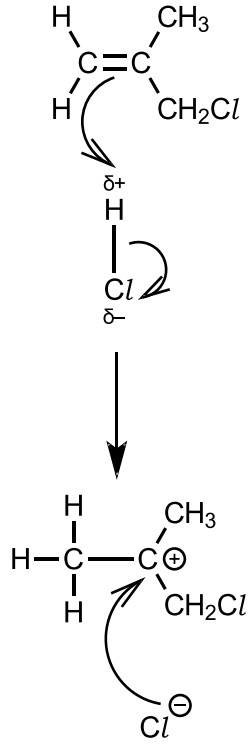
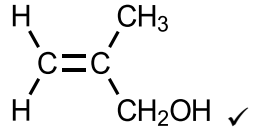
Mark Scheme

Question	Key	Marks	Guidance
1	B	**1**	
2	D	**1**	

Mark Scheme

Question			Answer	Marks	Guidance
3	(a)	(i)	C_4H_7Cl ✓	1	
		(ii)	 ✓	1	**DO NOT ALLOW** non-skeletal formulae
		(iii)	(compounds with) the same (molecular) formula **AND** different structures / structural formulae / arrangement of atoms / displayed formulae ✓	1	**ALLOW** same number of atoms of each element **ALLOW** different carbon backbone **DO NOT ALLOW** different spatial arrangement (of atoms)
	(b)		$n = \frac{pV}{RT} = \frac{(100 \times 10^3) \times (1.053 \times 10^{-3})}{8.314 \times 350}$ ✓ n = 0.0362 mol ✓ $M = \frac{m}{n} = \frac{1.321}{0.0362}$ = 36.5 (g mol^{-1}) ✓ *Identity* HCl ✓	4	
	(c)	(i)	From **Reaction 1** =  ✓ compound **B** =  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

Mark Scheme

Question			Answer	Marks	Guidance
		(ii)	 Curly arrow from C=C to attack the H atom ✓ Correct dipole on H—Cl **AND** curly arrow from bond to Cl ✓ Correct carbocation/carbonium ion with full positive charge shown **AND** correct curly arrow from negative charge of Cl^- to correct carbon atom **OR** correct curly arrow from lone pair of Cl^- to correct carbon atom ✓	**3**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous Curly arrow must start from covalent bonds and not atoms **DO NOT ALLOW** any other partial charges *e.g.* shown on double bond **DO NOT ALLOW** $C^{\delta+}$ for charge on carbonium ion. Curly arrow from Cl^- can start from the negative charge or the lone pair **DO NOT ALLOW** delta negative, *i.e.* C$l^{\delta-}$
		(iii)	because the <u>intermediate/carbocation</u> in the formation of compound **B** is <u>less stable</u> (than the intermediate in the formation of compound **A**) ✓	**1**	
		(iv)	 ✓ (Formation of) <u>white</u> precipitate/solid/suspension **AND** (ppt is) silver chloride/AgCl ✓	**2**	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

Mark Scheme

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(d)</td><td></td><td>

Use of elemental analysis data

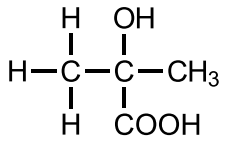
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>%</td><td>46.1</td><td>7.7</td><td>46.2</td></tr>
<tr><td>mol</td><td>3.84</td><td>7.7</td><td>2.89</td></tr>
<tr><td>ratio</td><td>1.33</td><td>2.66</td><td>1</td></tr>
</table>

atom ratio with calculation ✓
empirical formula = $C_4H_8O_3$ ✓

IR spectrum
(very) broad absorption 2500–3300 cm^{-1} (CO**OH**)
AND absorption 1640–1750 cm^{-1} (C=O) ✓
absorption 3450 cm^{-1} (alcohol **–OH**) ✓

Identification

conclusion from data: compound contains –COOH and –OH (empirical formula confirms no other C=O than in COOH) in place of the previous chlorine-containing groups



✓

</td><td>**5**</td><td>

ALLOW any values given within ranges given on Data Sheet

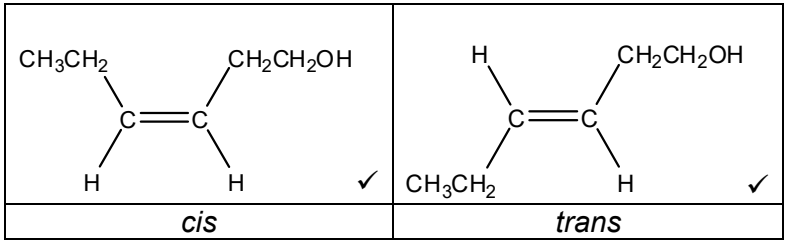
ALLOW correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous

</td></tr>
<tr><td></td><td></td><td></td><td>**Total**</td><td>**20**</td><td></td></tr>
</table>

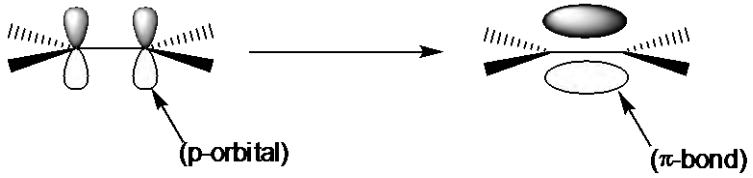
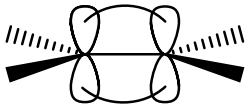
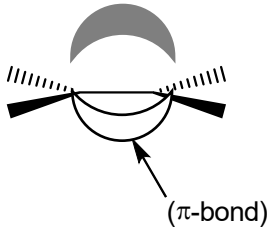
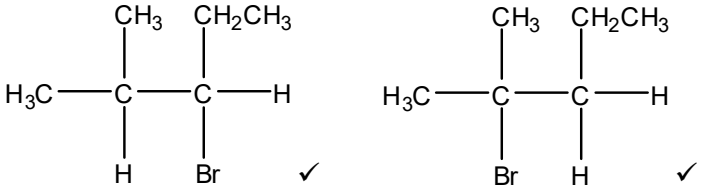
Mark Scheme

Question			Answer	Marks	Guidance
4	(a)		Compound **A** (is branched so) has less points of contact / less surface interaction between molecules ✓ Induced dipole–dipole interactions **/** London (dispersion) forces are weaker. **AND** Require less energy to break (these interactions / forces) ✓	**2**	**Both answers need to be comparisons** **ALLOW ORA** throughout **DO NOT ALLOW** 'more contact between atoms' **IGNORE** van der Waals' forces/VDW for induced dipole–dipole interactions (ambiguous as this term refers to both permanent dipole – dipole and induced dipole–dipole forces) **ALLOW** fewer induced dipole-dipole interactions. **IGNORE** it is easier to break the induced dipole-dipole / London forces. (reference to energy required) **IGNORE** less energy required to separate molecules **IGNORE** less energy is needed to break the bonds.
	(b)	(i)	Hex-3-en-1-ol ✓	**1**	**ALLOW** Hex-3-ene-1-ol **ALLOW** 1-hydroxyhex-3-ene as this is unambiguous Hex-3-enol is **not** sufficient **IGNORE** lack of hyphens, or addition of commas

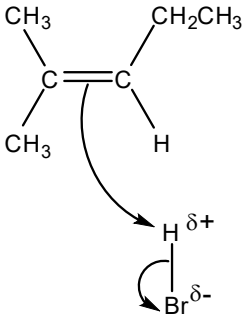
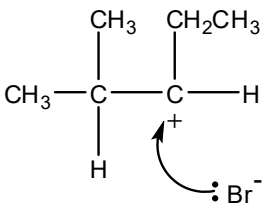
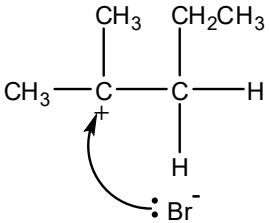
Mark Scheme

Question			Answer	Marks	Guidance
		(ii)	Same structural formula **AND** Different arrangement (of atoms) **in space OR** different **spatial** arrangement (of atoms) ✓	1	**ALLOW** have the same structure/displayed formula/skeletal formula **DO NOT ALLOW** same empirical formula **OR** same general formula **IGNORE** same molecular formula Reference to *E*/*Z* isomerism or optical isomerism is **not** sufficient
		(iii)	 *cis* *trans*	2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** one mark if both stereoisomers of compound **C** are shown but in the incorrect columns **ALLOW** one mark for correct stereoisomers of compound **C** in correct columns where – CH_2CH_2OH is represented as -C_2H_5O or – C_2H_4OH **DO NOT ALLOW** incorrect connectivity e.g. – CH_3CH_2 on first occasion but allow **ECF** in second structure.

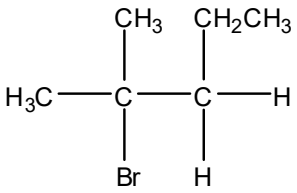
Mark Scheme

Question			Answer	Marks	Guidance
	(c)		 Two p-orbitals shown as a "dumb-bell" added to structure on left. **AND** π-bond on structure on right ✓	1	**DO NOT ALLOW** C=C in diagram **DO NOT ALLOW** overlapping p orbitals on left hand side in the diagram. **DO NOT ALLOW** a diagram that contains four lobes on the right hand side. e.g.  **IGNORE** any atoms joined to the bonds **Note:** labels are **not** required **ALLOW** the following diagram to show the π-bond 
	(d)	(i)	(The H atom of HBr) accepts a pair of electrons ✓	1	
		(ii)	 ✓ ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** a combination of above as long as unambiguous **ALLOW** in either order

Mark Scheme

Question	Answer	Marks	Guidance
(iii)	Curly arrow from C=C bond to H of H–Br ✓ Correct dipole shown on H–Br **AND** curly arrow showing the breaking of H–Br bond ✓  --- Correct carbocation **AND** curly arrow from Br^- to C^+ of carbocation ✓  **OR**  	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **DO NOT ALLOW** partial charges shown on C=C double bond (the second marking point) **DO NOT ALLOW** δ+ on C of carbocation Curly arrow must come from a lone pair on Br^- **OR** from the negative sign of Br^- ion (then lone pair on Br^- ion does not need to be shown)

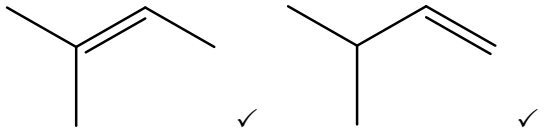
Mark Scheme

Question			Answer	Marks	Guidance
		(iv)	 2-bromo-2-methylpentane **AND** (the) **carbocation** intermediate (in the formation of 2-bromo-2-methylpentane) is more stable (than the carbocation in the formation of the other product) ✓	1	**Note:** the correct product and explanation are **both** required for the mark The major product may be identified by its • corresponding letter (**E** or **F**) from the table in **(d)(ii)** • correct structure • correct name **DO NOT ALLOW** product comes from the more stable **secondary or primary** carbocation **IGNORE** explanations based on Markownikoff's rule.
	(e)	(i)	n(myrcene) = $\frac{204 \times 10^{-3}}{136.0}$ = 1.5(0) × 10^{-3} (mol) ✓ Volume of H_2 = 3 × 1.5(0) × 10^{-3} × 24000 = 108 (cm^3) ✓	2	Correct working **required** for the first marking point. **ALLOW ECF** from incorrect moles of myrcene i.e. n(myrcene) × 3 × 24000 **Common incorrect answers** 108000 cm^3 = 1 mark (not converted to g) 12cm^3 = 1 mark (divided by 3) 36 cm^3 = 1 mark (not multiplied by 3) **IGNORE** Calculations based on $pV = nRT$

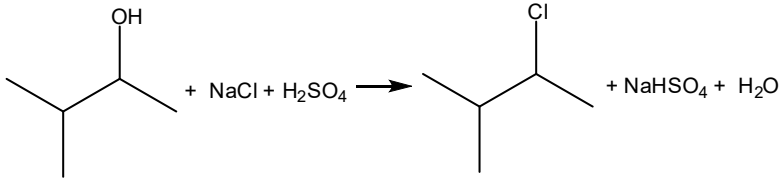
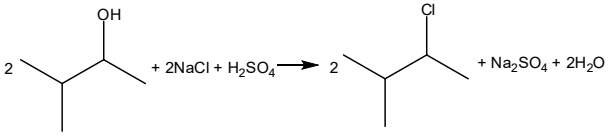
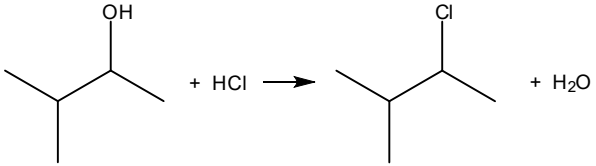
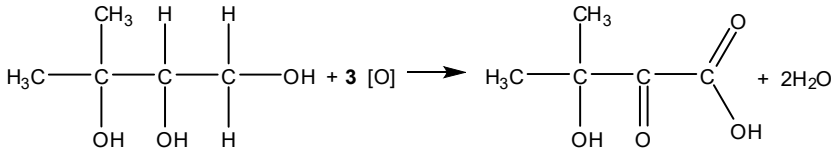
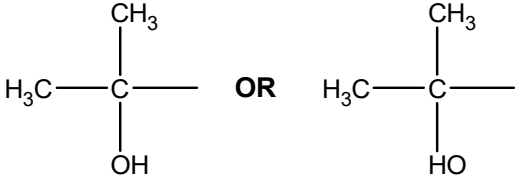
Mark Scheme

Question			Answer	Marks	Guidance
		(ii)	**Amount of hydrogen** $n(H_2) = \frac{5.28}{24.0} = 0.22(0)$ (mol) ✓ **Number of double bonds** $= \frac{0.220}{0.0200} = 11$ ✓ **Formula of saturated product** $C_{40}H_{78}$ ✓ **Equation** $C_{40}H_{56} + 11H_2 \longrightarrow C_{40}H_{78}$ ✓	**4**	**ALLOW** Evidence of $n(H_2) = \frac{5.28}{24.0}$ if 0.22 is not seen Evidence for 11 double bonds could come from $11H_2$ in equation Formula could be shown as the product of an equation **ALLOW ECF** from $C_{40}H_{82}$ and $C_{40}H_{80}$ **only** i.e. $C_{40}H_{60} + 11H_2 \longrightarrow C_{40}H_{82}$ $C_{40}H_{58} + 11H_2 \longrightarrow C_{40}H_{80}$
			Total	**20**	

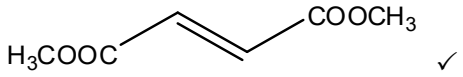
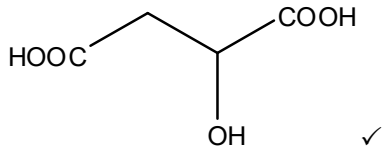
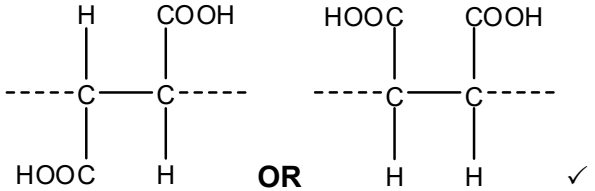
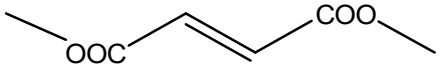
Mark Scheme

Question			Answer	Marks	Guidance
5	(a)	(i)	3-methylbutan-2-ol ✓	1	**IGNORE** lack of hyphens or addition of commas **ALLOW** 3-methylbutane-2-ol **DO NOT ALLOW** 2-methylbutan-3-ol **OR** 3-methylbut-2-ol **OR** 3-methbutan-2-ol **OR** 3-methybutan-2-ol **OR** 3-methlybutan-2-ol
		(ii)	$(CH_3)_2CHCHOHCH_3$ ✓	1	**ALLOW** brackets around OH e.g. $(CH_3)_2CHCH(OH)CH_3$ **ALLOW** any unambiguous structural formula e.g. $CH_3CH(CH_3)CHOHCH_3$ $CH_3CH(CH_3)CH(CH_3)OH$
		(iii)	One mark for each correct structure.  ✓ ✓	2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** in either order

Mark Scheme

Question			Answer	Marks	Guidance
		(iv)	 Correct haloalkane ✓ Correctly balanced equation ✓	2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW** H^+ for H_2SO_4 **ALLOW** equations forming Na_2SO_4  **ALLOW** equations with HCl  **DO NOT ALLOW** equations that form NaOH
	(b)		 Correct organic product ✓ Rest of equation ✓	2	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **ALLOW any** vertical bond to the tertiary OH group e.g. **ALLOW** 

Mark Scheme

Question	Answer	Marks	Guidance
(c)	**Product from excess CH_3OH/H_2SO_4**  ✓ **Product from steam, H_3PO_4**  ✓ **Repeat unit of polymer C**  ✓	3	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous e.g  **IGNORE** connectivity in each product **ALLOW** the *E* or *Z* isomer as product from excess CH_3OH/H_2SO_4 'End bonds' **MUST** be shown (do not have to be dotted) **IGNORE** brackets **IGNORE** *n* **ALLOW** more than one repeat unit but has to be a whole number of repeat units
	Total	**11**	