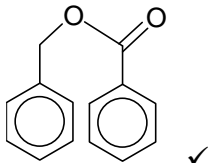
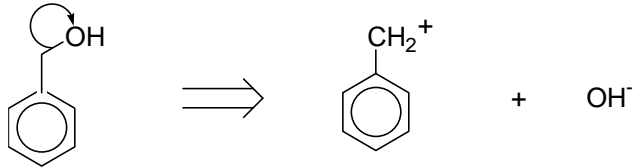
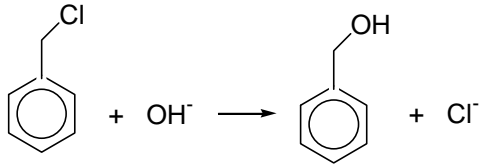
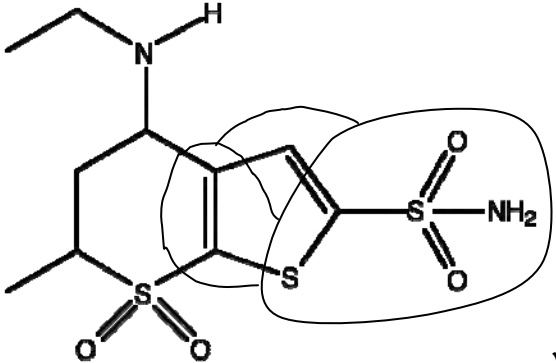
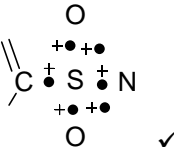
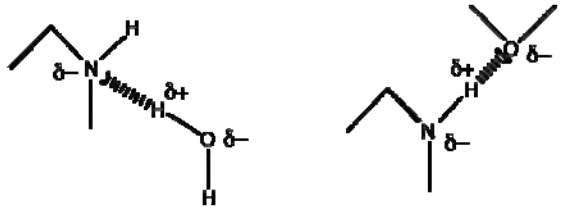
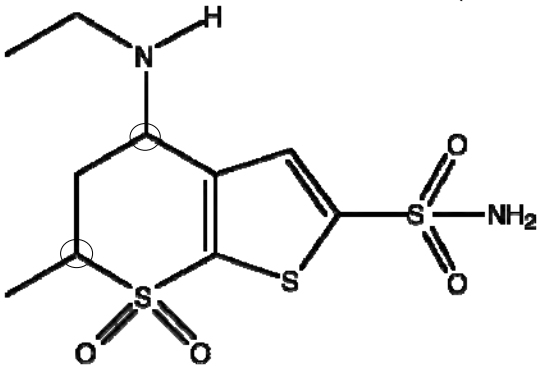
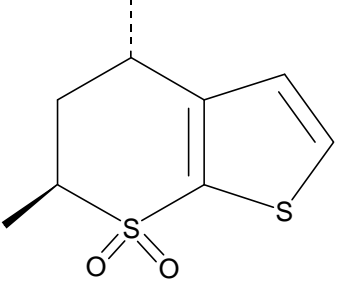


Question			Answer	Marks	Guidance
1	(a)	(i)		1	must be a correct skeletal formula
1		(ii)	C ₇ H ₆ O ₂ ✓	1	ALLOW atoms in different order
1		(iii)	concentrated sulfuric acid ✓ heat / reflux / high temperature ✓	2	ALLOW any abbreviation for concentrated 'moderately' is CON to first mark ALLOW conc hydrochloric acid ALLOW formulae second mark depends on mention of correct acid (not necessarily concentrated) in first Extra reagents (eg dichromate) CON both marks IGNORE 'alcohol' or references to the reagents
1		(iv)	step 1: oxidation ✓ step 2: condensation ✓	2	ALLOW 'addition elimination'
1	(b)	(i)	one mark for 230 as divisor ✓ one mark for the expression and its evaluation ✓ $\frac{212}{230} \times 100 = 92.2\%$	2	ALLOW ecf from wrong divisor if working shown ALLOW two or more sf Any answer that rounds (from above) to 92 scores both marks
1		(ii)	little waste OR most reagents/atoms used ✓	1	ALLOW fewer/less waste (product)/ coproduct IGNORE less byproducts IGNORE 'less raw materials required' IGNORE 'toxic'

Question			Answer	Marks	Guidance
1	(c)	(i)	 <p>curly arrow ✓ synthons ✓</p>	2	arrow must go from bond (if projected) and point to O ALLOW — ⁺ on cation but not just C ⁺ ALLOW without plus sign between synthons IGNORE lone pairs on OH
1		(ii)	 <p>'benzyl chloride' correct ✓ full equation ✓</p>	2	ALLOW any structural or molecular formulae for organics NOT H ₂ O replacing OH ⁻ ALLOW [OH ⁻] or [OH] ⁻ ALLOW NaOH/KOH as reagent and NaCl/KCl as product
			Total	13	

Question			Answer	Marks	Guidance
2	(a)	(i)	part/area/region of the molecule/structure/compound that <i>either</i> binds/bonds/fits to a receptor/enzyme/active site <i>or</i> is responsible for the medicinal/pharmacological action/ acts as the drug (AW) ✓	1	IGNORE 'functional group' or 'drug' must make it clear that it is 'part' and 'of molecule' must say 'part of molecule' (AW) AND then the <i>either/or</i> ALLOW produces biological response/biologically active NOT just 'activity'
		(ii)	 ✓	1	The right-hand ring, which can be extended to the left or above as shown If 'circle' cuts the double bond it can do so anywhere, including through the bottom C atom ALLOW ring on compound A
2	(b)	(i)	 ✓	1	must be dot not open circle, but can be 'x' not '+'
		(ii)	109 ✓ 4 groups /sets of <u>electrons</u> OR 4 regions/areas of <u>electron</u> (density) ✓ electrons/bonds/bonding pairs/negative charges repel ✓ electrons/bonds/bonding pairs/negative charges get as far away from each other as possible ✓	4	ALLOW 105 – 110 NOT bonds NOT electron pairs (unless by ecf from b(i)) NOT atoms ALLOW electron pairs for this mark ALLOW 'minimise repulsion' (for last two marks) NOT 'maximise repulsion' for last mark ALLOW 'repel as far as possible' for last two marks
2	(c)	(i)	$[H^+] = 1 \times 10^{-8}$ ✓ $[OH^-] = 1 \times 10^{-6}$ ✓	2	correct answer scores 2 without inspection of working ALLOW ecf from value of $[H^+]$ which gives an answer greater than 1×10^{-7} Value of $[H^+]$ must be identified by at least ' $H^+ =$ ' ALLOW ' 10^{-6} ' for ' 1×10^{-6} ' etc

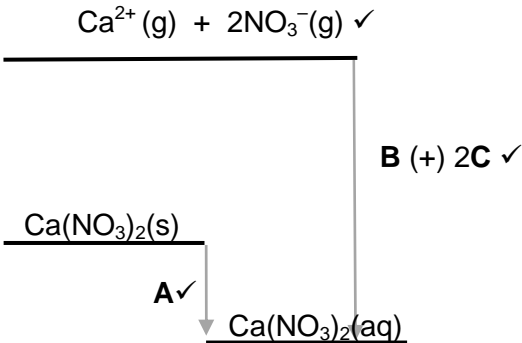
Question			Answer	Marks	Guidance
2	(c)	(ii)	1. Phenol ✓ 2. phenol/hydroxyl/OH... reacts with alkali(ne)/OH ⁻ OR is acidic OR is deprotonated AW OR donates protons OR forms O ⁻ ✓ 3. to give ions/ionic (substance) ✓ 4. ions are soluble ✓	4	1. NOT alcohol or hydroxyl 2. must refer to a phenol/ hydroxyl/ OH group to score (ALLOW 'alcohol') ALLOW 'H ⁺ ' for protons but IGNORE hydrogen/H IGNORE 'base/basic' 3 and 4 can be scored without 1 and 2, 4. includes 3 if ions/ionic mentioned 4. ALLOW salts are soluble 4. ALLOW forms ion(ic)-dipole (interaction) with water molecules IGNORE references to hydrogen bonds
		(iii)	alkali(ne)/ OH ⁻ ions damage/harmful to/irritate/sting... <u>the eye</u> ✓	1	Both parts necessary for mark
2	(d)		 hydrogen bond coming from upper N or H but not both together ✓ partial charges on H, N and O ✓ lone pair on N or O (as appropriate) touching bond ✓	3	hydrogen bonds shown as illustrated or as ----- IGNORE additional correct hydrogen bonds, even if not fully adorned with lone pairs or partial charges Extra incorrect hydrogen bonds are CON to the first mark. If correct hydrogen bond is not shown, allow marks 2 and 3 on another hydrogen bond between water and an appropriate atom on the molecule

Question	Answer	Marks	Guidance
2 (e)	<p>correct two chiral centres indicated (on either diagram) ✓</p>  <p>one wedge on one and one dotted line on the other ✓</p> 	2	<p>Second mark depends on first</p> <ul style="list-style-type: none"> • Groups (eg NH, CH₃) need not be shown on the bonds but if they are either the groups or hydrogen atoms must be 'trans'. • If both wedge and dotted line shown on a chiral carbon, groups (eg NH, CH₃ or H) must be shown (and must be 'trans'). • If a wedge or a dotted line and a straight line is shown on a chiral carbon, ignore straight line. <p>IGNORE additions to other than chiral carbons</p> <p>wedge must be coming out (i.e. 'thin end' nearest ring)</p>
2 (f) (i)	(secondary) amide ✓	1	NOT 'primary amide'
	(ii) ammonia/ NH ₃ ✓	1	IGNORE 'concentrated', 'dilute', 'solution'
2 (g) (i)	$\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{H}^+$ ✓	1	<p>IGNORE state symbols</p> <p>Must have equilibrium sign</p> <p>ALLOW $\text{CO}_2 + 2\text{H}_2\text{O} \rightleftharpoons \text{HCO}_3^- + \text{H}_3\text{O}^+$</p>

Question			Answer	Marks	Guidance
2	(g)	(ii)	(inhibitor) binds with / forms bonds with / fits into the active site (of the enzyme) ✓ (inhibitor) blocks the active site/receptor site OR competes with the <u>substrate</u> OR <u>substrate</u> cannot bind/fit/react (with the active site) OR stops <u>substrate</u> being broken down/reacted/catalysed OR fewer/less <u>active sites</u> available ✓	2	ALLOW combine with another part of enzyme ALLOW changing shape of active site
			Total	24	

Question			Answer	Marks	Guidance
3	(a)	(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ ✓	1	ALLOW upper case letters IGNORE $3d^0$ NOT subscripts NOT [Ar] $4s^2$
		(ii)	$2+ / +2$ AND Group 2 / second group ✓	1	
		(iii)	<p>$Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$ equation AND state symbols ✓</p> <p>(2nd IE) removing electron from shell further from nucleus / (3rd IE) removing electron from shell closer to nucleus ✓</p> <p>(2nd IE) (electron experiences) less attraction / (3rd IE) (electron experiences) more attraction ✓</p>	3	<p>ALLOW $Ca^+(g) - e^- \rightarrow Ca^{2+}(g)$ must be Ca not 'X' etc. ALLOW electron without minus sign IGNORE state symbols for electron</p> <p>ALLOW 'energy level' for 'shell' ALLOW Ca^{2+} is smaller than Ca^+</p> <p>mark separately ALLOW 'held more tightly' AW ora IGNORE references to energy required</p>
3	(b)		oxidation state/number of <u>nitrogen/N</u> (in the ion) OR <u>nitrogen/N</u> has oxidation state/number of (+) 5 ✓	1	'in molecule' is CON '-5' is CON
3	(c)	(i)	$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$ ✓	1	IGNORE state symbols
		(ii)	<p>(contains) N/nitrogen/nitrate which crops/plants need ✓ OR soluble source of nitrogen/nitrate ✓</p>	1	For mark, must have idea of crops or plants AND their need of nitrogen/nitrate (or 'grow better with' OR named use eg making amino acids/DNA) OR mention of solubility AND nitrogen/nitrate
3	(d)	(i)	$x = 4$ ✓✓	2	For one mark look for: $8.2/164.1 = 0.05$ (or more sf) OR $3.6/18 = 0.2$ Both expression and answer required for one mark ALLOW 164 for 164.1

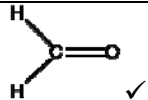
Question			Answer	Marks	Guidance
3	(d)	(ii)	$\text{Ca}(\text{NO}_3)_2(\text{s}) \rightarrow \text{CaO}(\text{s}) + 2\text{NO}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$ CaO and NO ₂ as products ✓ correct equation (or doubled) ✓ state symbols correct for Ca(NO ₃) ₂ , CaO, one of NO/NO ₂ /N ₂ O, – and O ₂ if present – all on correct sides of equation ✓	3	
		(iii)	reference to ions or ionic structure ✓ strong electrostatic forces OR strong attraction forces between ions OR strong ionic bonds OR a lot of energy needed to break ionic bonds ✓	2	reference to covalent bonds or molecules or shared electrons CONs first mark ALLOW 'Ca ²⁺ and O ²⁻ ' for 'ions' IGNORE references to inter/intramolecular bonds/forces
3	(e)	(i)	+46 ✓✓	2	One mark for: EITHER (2 x 146) – 53 – 193 with wrong evaluation OR one error in above expression (or round the wrong way) with correct evaluation 46 scores 1 without working –46 (wrong way round) scores 1 without working –100 (factor of 2 omitted) scores 1 without working (these numbers with no sign do not score)

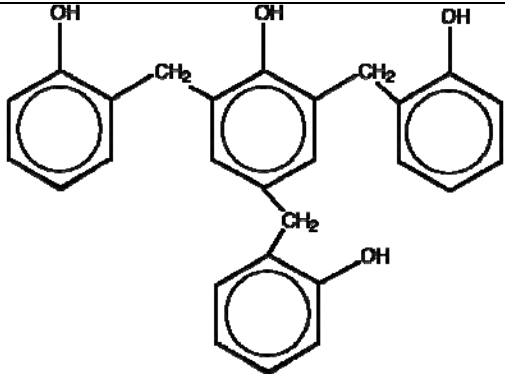
Question			Answer	Marks	Guidance
		(ii)	$\Delta S^{\circ}_{\text{tot}} = (\text{ans to e(i)}) + 19000/298) \checkmark$ correctly evaluated \checkmark (19000/298 = 63.758)	2	If e(i) is correct, answer is +110 (ALLOW +109.8 or more sf rounding to +109.8) (in general, 2 or more sf) + sign must be there for second mark to be awarded ALLOW correctly evaluated [(ans to e(i)) + 19/298] (answers rounding to +46 or +46.1) for one mark OR correctly evaluated [(ans to e(i)) – 19000/298] (answers rounding to –18 or –17.8) for one mark No other ecf from first mark to second. Any correct answer with correct sign can be awarded the mark(s) even if no working is shown no ecf on missing + signs
(f)	(i)		 <p>lattice enthalpy = – \checkmark1963 \checkmark</p>	5	ALLOW A, B and C in words or numbers IGNORE lattice enthalpy labelled ALLOW 'B(+)C' OR 'B(+)2C' if only one nitrate ion shown on upper level in words 'enthalpy (change) of hydration of Ca ²⁺ /calcium ions plus twice enthalpy (change) of hydration of NO ₃ [–] /nitrate / enthalpy (change) of hydration of 2NO ₃ [–] ' One mark for any negative number on answer line No ecf for calculation, except –1797/–1800 scores both marks if ' B + C ' shown for the hydration term, but allow 'correct' answer even if 'B+C' written '1963' without sign (or + sign) scores one of last two marks
		(ii)	ion-dipole (forces/bonds) \checkmark	1	ALLOW without hyphen NOT 'ionic-dipole'
			Total	25	

Question			Answer	Marks	Guidance
4	(a)	(i)	nitrobenzene ✓	1	ALLOW nitro benzene/ 1-nitrobenzene
		(ii)	water ✓	1	ALLOW H ₂ O
		(iii)	molybdenum(VI) oxide ✓	1	NOT molybdenum trioxide or molybdenum(VI) trioxide ALLOW gap between 'molybdenum' and 'VI' "molybdenum" must be spelled correctly
4	(b)		M_r values 78.0 and 123.0 ✓ a number rounding to 40.1 (ecf from incorrect M_r values) ✓ 40.1 (3sf) (ecf from incorrect M_r values) ✓	3	ALLOW 78 and 123 For sf mark, allow any number with 3sf resulting from a shown correct calculation
4	(c)		more energy used ora ✓ higher temperature / 140 ora ✓	2	ALLOW 'more fossil fuels burnt' AW If the answer 'jumps' from one method to the other and is thus inconsistent, mark first statement and ignore the rest ALLOW Mo is a heavy metal ✓ Mo is toxic ✓
4	(d)	(i)	nitric acid/HNO ₃ as it is accepting a proton/H ⁺ ✓	1	Both nitric acid AND proton acceptor required for the mark
		(ii)	sulfuric acid... donates/gives/pushes(AW) a proton on to nitric acid OR makes nitric acid act as a base OR acts as an acid with nitric acid / in the mixture OR nitric acid accepts a proton from sulfuric acid ✓	1	Both name and reason for one mark answer must refer to nitric acid or the mixture ALLOW formulae for the acids
		(iii)	acid: H ₂ SO ₄ base: HSO ₄ ⁻ ✓	1	
		(iv)	HNO ₃ → H ⁺ + NO ₃ ⁻ OR HNO ₃ + H ₂ O → H ₃ O ⁺ + NO ₃ ⁻ ✓ pH = 1.82 ✓	2	NOT equilibrium sign, NOT [H ⁺] [NO ₃ ⁻] ALLOW '(+aq)' on left hand side of top equation IGNORE state symbols ALLOW any value rounding to 1.8 NOT '2'

Question			Answer	Marks	Guidance
4	(d)	(v)	mention of half-neutralised in some way (eg answers not including dilution effect: 0.0075 M; pH = 2.12; moles H^+ = 1.5×10^{-4} moles) ✓ pH = 2.30 ✓	2	Correct pH (any number rounding to 2.3) scores both marks without reference to working NOT just a mention of 1.5×10^{-4}
	(e)		delocalised (electrons) ✓ one electron from each carbon ✓ two rings (of electrons) ✓ above and below <u>carbon atoms / carbon ring</u> ✓ <i>Mark separately</i>	4	QWC 'delocalised' must be spelled correctly to score first mark ALLOW 'delocalized' or derivations such as 'delocalisation' ALLOW 'six electrons from six carbons' ALLOW 'one electron from one carbon' 'Above and below' in last point will cover the 'two' in the previous point 'carbon ring' covers 'ring' aspect of mp3 IGNORE 'either side of C atoms' ALLOW last two marking points from a labelled diagram
	(f)	(i)	Sn and (conc) HCl ✓ HNO_2 (/HCl// H^+) OR NaNO_2 and H^+ /HCl ✓ phenol (or formula) ✓	3	ALLOW names throughout NOT HNO_3 IGNORE H_2SO_4 IGNORE 'conc' before HCl IGNORE NaOH / alkaline conditions other reagents are CON
		(ii)	alkali(ne) conditions / NaOH ✓ low temperature ✓	2	ALLOW 'NaOH/alkaline' if in reagent box from f(i) ALLOW a quoted temperature below 10°C OR reference to ice IGNORE irrelevant conditions but inconsistent ones eg 'anhydrous' or 'heat' or 'reflux' are CON to the appropriate mark

Question			Answer	Marks	Guidance
4	(f)	(iii)	<p>1. electron excited/moves up to higher (energy) level ✓</p> <p>2. $\Delta E = h\nu/f$ OR energy <u>gap/difference</u> corresponds to frequency ✓</p> <p>3. benzene absorbs UV (light) AND dyes absorb (visible) light OR benzene's ΔE corresponds to UV / benzene's ΔE is too large for it to absorb visible light / visible light cannot excite benzene's electrons AND dye's ΔE corresponds to visible / dyes absorb visible ✓</p> <p>4. (dyes) transmit/reflect complementary colour ✓</p> <p>5. dyes have more delocalisation (than benzene) (ora) ✓</p> <p>6. more delocalisation reduces ΔE/ energy levels closer/ less energy to excite (ora) ✓</p>	6	<p>ALLOW 'compound' for 'dye' throughout IGNORE references to d orbitals QWC (link mark): only award second mark if first mark scored ALLOW '$E = h\nu$' (no Δ) only if in context of energy change</p> <p>IGNORE 'emits' but reference to electrons giving out light on dropping down – 3 max (cannot be point 4)</p> <p>both dye's and benzene's absorption must be mentioned but can be in different parts of the answer</p> <p>ALLOW 'frequency not absorbed is transmitted' AW</p> <p>must be comparative, but it can be assumed that the other (dye or benzene) is being compared</p> <p>For 'more delocalisation' ALLOW 'extended delocalisation' / 'larger [or extended] chromophore' / 'more conjugated'</p>
			Total	30	

Question			Answer	Marks	Guidance									
5	(a)		 methanal ✓	2	must have all bonds and atoms shown but any bond angles									
5	(b)		formaldehyde/methanal has permanent dipole–permanent dipole bonds ✓ methanol has hydrogen bonds ✓ hydrogen bonds/imb in methanol are stronger / higher bond enthalpy (ora) ✓ more energy needed to separate (molecules)/ break imb (ora) OR enough energy at room temperature to break imb in formaldehyde/methanal but not methanol ✓	4	NO abbreviations, ALLOW ‘forces’ for ‘bonds’ (except that ‘hydrogen bonds’ must be given) ignore any weaker imb described for each last two marking points must be comparisons, though the comparison can be in different parts of the answer eg strong hydrogen bonds... weak permanent dipole–permanent dipole Comparisons of any imb are acceptable for the last two marking points ALLOW ‘hydrogen bonds strongest (imb)’ QWC only award fourth marking point if third has been scored									
5	(c)	(i)	<table border="1"><tr><td>increase</td><td>increase</td><td>increase</td></tr><tr><td>decrease</td><td>decrease</td><td>no change</td></tr><tr><td>✓</td><td>✓</td><td>✓</td></tr></table> one mark for each correct column	increase	increase	increase	decrease	decrease	no change	✓	✓	✓	3	
increase	increase	increase												
decrease	decrease	no change												
✓	✓	✓												
		(ii)	compromise between rate (AW) and yield (AW) ✓	1	IGNORE references to catalyst must imply compromise and mention rate (AW) and yield (AW)									
5	(d)	(i)	$(K_c =) [\text{H}_2\text{O}]^2 [\text{HCHO}]^2 / [\text{CH}_3\text{OH}]^2 [\text{O}_2] \checkmark$	1	must have square brackets and correct powers may have multiplication signs									

Question			Answer	Marks	Guidance
5	(d)	(ii)	pressure: no effect / no change ✓ temperature: decreases / gets smaller / goes down ✓	2	
	(e)		Over all temps because ΔS_{tot} always positive ✓ $\Delta S_{\text{tot}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$ ✓ ΔS_{sys} positive since more molecules on rhs ✓ ΔS_{surr} positive, since ΔH neg (AW) ✓	4	ALLOW 'entropy increases since more moles on rhs (AW)' for one mark if no others scored ALLOW use of ' $-\Delta H/T$ ' for ' ΔS_{surr} ' for 2 nd and 4 th marking points
	(f)	(i)	 <p>one $-\text{CH}_2-$ link correct ✓ both correct ✓</p>	2	ALLOW 'bridge' at 4 position on top two phenol rings ALLOW $-\text{CH}_2-$ straight not just lines joining rings Other links are CON
		(ii)	condensation because water/small molecule is eliminated (AW)	1	
		(iii)	giant (covalent) OR covalent network ✓	1	IGNORE atomic, lattice NOT ionic, metallic

Question			Answer	Marks	Guidance
	(g)	(i)	no O–H / alcohol / hydroxyl ✓ no C=O / carbonyl OR molecule is saturated ✓ contains oxygen/O OR can only have C–O ✓	3	IGNORE wavenumber ranges IGNORE statements about other bonds IGNORE other names of groups containing C=O
		(ii)	triplet – adjacent C has 2 Hs ✓ quartet – adjacent C has 3 Hs ✓	2	for 'triplet' ALLOW any unambiguous identification or range for 'quartet' ALLOW any unambiguous identification or range IGNORE references to peak height/area ALLOW 'protons' for 'Hs' but NOT 'H' ALLOW 'environment of 2/3 Hs' or 2/3 neighbouring Hs correctly stated for <i>both</i> peaks as ecf for one mark
		(iii)	C ₂ H ₅ OCH ₂ OC ₂ H ₅ ✓ singlet means that CH ₍₂₎ is not attached to a carbon with hydrogens (AW) ✓	2	ACCEPT any correct structural formula ALLOW any unambiguous way of describing this peak ALLOW 'environment of no Hs' or 'no neighbouring Hs' mark separately ALLOW 'no hydrogens on adjacent carbon'
			Total	28	