

**Chemistry B (Salters)**

Advanced GCE

Unit **F335**: Chemistry by Design

**Mark Scheme for January 2013**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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**Annotations** used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	separates marking points
<b>not</b>	answers which are not worthy of credit and which will CON a correct answer
<b>ignore</b>	statements which are irrelevant and will NOT 'CON' a correct answer
<b>allow</b>	answers that can be accepted
( )	words which are not essential to gain credit
—	underlined words must be present in answer to score a mark
ecf	error carried forward
AW	alternative wording (replaces the old 'or words to that effect')
ora	or reverse argument

**Annotations** used in scoris:

Annotation	Meaning
	correct response
	incorrect response
	benefit of the doubt
	benefit of the doubt <b>not</b> given
	error carried forward
	information omitted
	Ignore
	Reject

**Subject-specific Marking Instructions**

Accept minor mis-spellings where the 'sound' is right (eg alcahol), except:

- QWC mark
- where it changes a technical term (eg alkene/alkane)

If the answer on the answer line (or in box) differs from a previous answer (copying error), mark the answer on the answer line (or in box).  
If the answer line (or box) is blank, reward the answer elsewhere if possible.

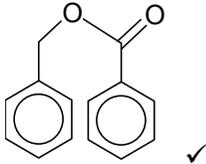
In calculations, rounding errors should not be rewarded, unless the Mark Scheme indicates otherwise.

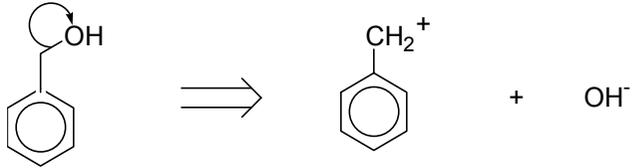
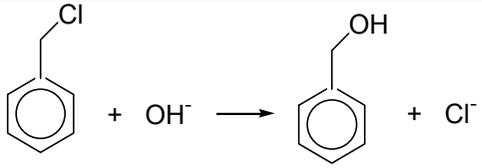
If it says 'mark separately' marks can be awarded even if the answer does not hang together well without the other mark. However, if the later marking point has words in brackets before it, the mark should only be awarded in the context of those words.

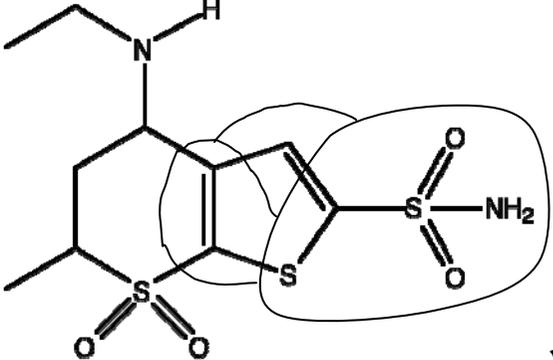
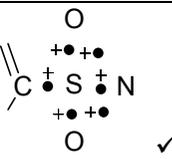
Formulae must have correct brackets and subscripts to score. Element symbols must have small second letters (eg not BA). These errors and the use of a wrong symbol should, if possible, only result in the loss of ONE mark in a part (rather than more marks).

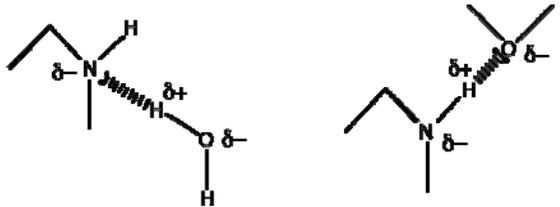
Multiples of equations are acceptable (including halves) unless specified otherwise.

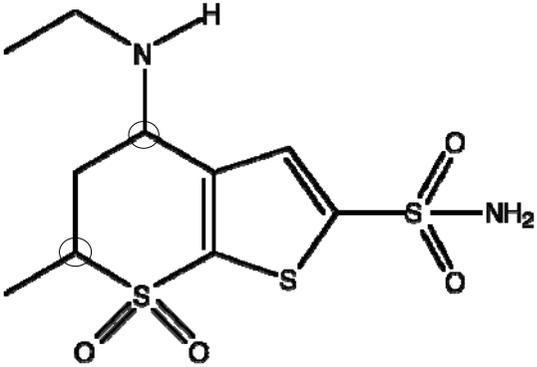
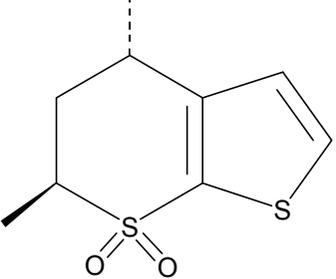
Allow the omission of one plus sign in an equation if the species are still well separated.

Question			Answer	Marks	Guidance
1	(a)	(i)		1	must be a correct skeletal formula
1		(ii)	$C_7H_6O_2$ ✓	1	<b>ALLOW</b> atoms in different order
1		(iii)	concentrated sulfuric acid ✓  heat / reflux / high temperature ✓	2	<b>ALLOW</b> any abbreviation for concentrated 'moderately' is CON to first mark <b>ALLOW</b> conc hydrochloric acid <b>ALLOW</b> formulae second mark depends on mention of correct acid (not necessarily concentrated) in first Extra reagents (eg dichromate) CON both marks <b>IGNORE</b> 'alcohol' or references to the reagents
1		(iv)	step 1: oxidation ✓ step 2: condensation ✓	2	<b>ALLOW</b> '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	<b>ALLOW</b> ecf from wrong divisor if working shown <b>ALLOW</b> two or more sf Any answer that rounds (from above) to 92 scores both marks
1		(ii)	little waste <b>OR</b> most reagents/atoms used ✓	1	<b>ALLOW</b> fewer/less waste (product)/ coproduct <b>IGNORE</b> less byproducts <b>IGNORE</b> 'less raw materials required' <b>IGNORE</b> '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 <b>ALLOW</b> — <sup>+</sup> on cation but not just C <sup>+</sup> <b>ALLOW</b> without plus sign between synthons <b>IGNORE</b> lone pairs on OH
1		(ii)	 <p>'benzyl chloride' correct ✓ full equation ✓</p>	2	<b>ALLOW</b> any structural or molecular formulae for organics <b>NOT</b> H <sub>2</sub> O replacing OH <sup>-</sup> <b>ALLOW</b> [OH] or [OH] <sup>-</sup> <b>ALLOW</b> NaOH/KOH as reagent and NaCl/KCl as product
<b>Total</b>				<b>13</b>	

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	<b>IGNORE</b> 'functional group' or 'drug' must make it clear that it is 'part' and 'of molecule' must say 'part of molecule' (AW) <b>AND</b> then the <i>either/or</i> <b>ALLOW</b> produces biological response/biologically active <b>NOT</b> 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  <b>ALLOW</b> 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> <b>OR</b> 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	<b>ALLOW</b> 105 – 110 <b>NOT</b> bonds <b>NOT</b> electron pairs (unless by ecf from b(i)) <b>NOT</b> atoms <b>ALLOW</b> electron pairs for this mark <b>ALLOW</b> 'minimise repulsion' (for last two marks) <b>NOT</b> 'maximise repulsion' for last mark <b>ALLOW</b> '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 <b>ALLOW</b> ecf from value of $[H^+]$ which gives an answer greater than $1 \times 10^{-7}$ Value of $[H^+]$ must be identified by at least 'H <sup>+</sup> =' <b>ALLOW</b> '10 <sup>-6</sup> ' for '1 x 10 <sup>-6</sup> ' etc

Question		Answer	Marks	Guidance
2	(c) (ii)	1. Phenol ✓ 2. phenol/hydroxyl/OH... reacts with alkali(ne)/OH <sup>-</sup> <b>OR</b> is acidic <b>OR</b> is deprotonated AW <b>OR</b> donates protons <b>OR</b> forms O <sup>-</sup> ✓ 3. to give ions/ionic (substance) ✓ 4. ions are soluble ✓	4	1. <b>NOT</b> alcohol or hydroxyl 2. must refer to a phenol/ hydroxyl/ OH group to score ( <b>ALLOW</b> 'alcohol') <b>ALLOW</b> 'H <sup>+</sup> ' for protons but <b>IGNORE</b> hydrogen/H <b>IGNORE</b> 'base/basic'  3 and 4 can be scored without 1 and 2, 4. includes 3 if ions/ionic mentioned 4. <b>ALLOW</b> salts are soluble 4. <b>ALLOW</b> forms ion(ic)-dipole (interaction) with water molecules <b>IGNORE</b> references to hydrogen bonds
	(iii)	alkali(ne)/ OH <sup>-</sup> 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 ----- <b>IGNORE</b> 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><b>Second mark depends on first</b></p> <ul style="list-style-type: none"> <li>• Groups (eg NH, CH<sub>3</sub>) need not be shown on the bonds but if they are either the groups or hydrogen atoms must be 'trans'.</li> <li>• If both wedge and dotted line shown on a chiral carbon, groups (eg NH, CH<sub>3</sub> or H) must be shown (and must be 'trans').</li> <li>• If a wedge or a dotted line <b>and</b> a straight line is shown on a chiral carbon, ignore straight line.</li> </ul> <p><b>IGNORE</b> 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	<b>NOT</b> 'primary amide'
	(ii) ammonia/ NH <sub>3</sub> ✓	1	<b>IGNORE</b> 'concentrated', 'dilute', 'solution'
2 (g) (i)	CO <sub>2</sub> + H <sub>2</sub> O ⇌ HCO <sub>3</sub> <sup>-</sup> + H <sup>+</sup> ✓	1	<p><b>IGNORE</b> state symbols</p> <p>Must have equilibrium sign</p> <p><b>ALLOW</b> CO<sub>2</sub> + 2H<sub>2</sub>O ⇌ HCO<sub>3</sub><sup>-</sup> + H<sub>3</sub>O<sup>+</sup></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 <b>OR</b> competes with the <u>substrate</u> <b>OR</b> <u>substrate</u> cannot bind/fit/react (with the active site) <b>OR</b> stops <u>substrate</u> being broken down/reacted/catalysed <b>OR</b> fewer/less <u>active sites</u> available ✓	2	<b>ALLOW</b> combine with another part of enzyme <b>ALLOW</b> changing shape of active site
			<b>Total</b>	<b>24</b>	

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

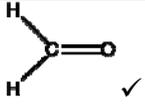
Question			Answer	Marks	Guidance
3	(d)	(ii)	$\text{Ca}(\text{NO}_3)_2(\text{s}) \rightarrow \text{CaO}(\text{s}) + 2\text{NO}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$ CaO and NO <sub>2</sub> as products ✓ correct equation (or doubled) ✓ state symbols correct for Ca(NO <sub>3</sub> ) <sub>2</sub> , CaO, one of NO/NO <sub>2</sub> /N <sub>2</sub> O, – and O <sub>2</sub> if present – all on correct sides of equation ✓	3	
		(iii)	reference to ions or ionic structure ✓ strong electrostatic forces <b>OR</b> strong attraction forces between ions <b>OR</b> strong ionic bonds <b>OR</b> a lot of energy needed to break ionic bonds ✓	2	reference to covalent bonds or molecules or shared electrons CONs first mark <b>ALLOW</b> 'Ca <sup>2+</sup> and O <sup>2-</sup> ' for 'ions' <b>IGNORE</b> references to inter/intramolecular bonds/forces
3	(e)	(i)	+46 ✓✓	2	One mark for: <b>EITHER</b> (2 x 146) – 53 – 193 with wrong evaluation <b>OR</b> <b>one</b> 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)

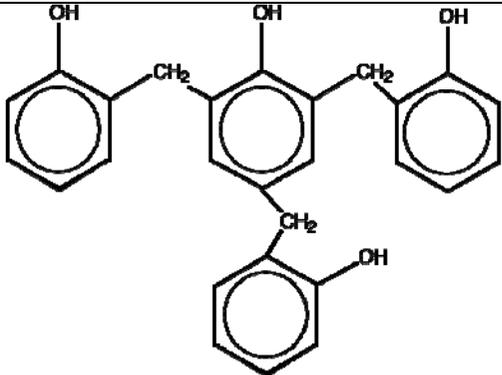
Question	Answer	Marks	Guidance
	<p>(ii) <math>\Delta S^{\ominus}_{\text{tot}} = (\text{ans to e(i)}) + 19000/298</math> ✓</p> <p>correctly evaluated ✓</p> <p>(19000/298 = 63.758)</p>	2	<p>If e(i) is correct, answer is +110 (<b>ALLOW</b> +109.8 or more sf rounding to +109.8) (in general, 2 or more sf) + sign must be there for second mark to be awarded</p> <p><b>ALLOW</b> correctly evaluated [(ans to e(i)) + 19/298] (answers rounding to +46 or +46.1) for one mark</p> <p><b>OR</b> correctly evaluated [(ans to e(i)) – 19000/298] (answers rounding to –18 or –17.8) for one mark</p> <p>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</p>
(f)	<p>(i)</p> <div style="text-align: center;"> <math display="block">\text{Ca}^{2+}(\text{g}) + 2\text{NO}_3^{-}(\text{g}) \checkmark</math> <hr style="width: 20%; margin: 0 auto;"/> <div style="display: flex; align-items: center; justify-content: center;"> <div style="margin-right: 20px;"> <math display="block">\text{Ca}(\text{NO}_3)_2(\text{s})</math> <hr style="width: 10%; margin: 0 auto;"/> <p style="margin: 0;">A ✓</p> </div> <div style="border-left: 1px solid black; height: 100px; margin: 0 10px;"></div> <div style="margin-left: 20px;"> <math display="block">\text{Ca}(\text{NO}_3)_2(\text{aq})</math> <hr style="width: 10%; margin: 0 auto;"/> </div> </div> <p style="text-align: right; margin-right: 20px;">B (+) 2C ✓</p> <p>lattice enthalpy = – ✓1963 ✓</p> </div> <td data-bbox="1142 683 1265 1295">5</td> <td data-bbox="1265 683 2080 1295"> <p><b>ALLOW A, B and C</b> in words or numbers <b>IGNORE</b> lattice enthalpy labelled</p> <p><b>ALLOW</b> 'B(+)'C' <b>OR</b> 'B(+)'2C' if only one nitrate ion shown on upper level in words 'enthalpy (change) of hydration of <math>\text{Ca}^{2+}</math>/calcium ions plus twice enthalpy (change) of hydration of <math>\text{NO}_3^{-}</math>/nitrate / enthalpy (change) of hydration of <math>2\text{NO}_3^{-}</math>'</p> <p>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</p> </td>	5	<p><b>ALLOW A, B and C</b> in words or numbers <b>IGNORE</b> lattice enthalpy labelled</p> <p><b>ALLOW</b> 'B(+)'C' <b>OR</b> 'B(+)'2C' if only one nitrate ion shown on upper level in words 'enthalpy (change) of hydration of <math>\text{Ca}^{2+}</math>/calcium ions plus twice enthalpy (change) of hydration of <math>\text{NO}_3^{-}</math>/nitrate / enthalpy (change) of hydration of <math>2\text{NO}_3^{-}</math>'</p> <p>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</p>
	(ii) ion-dipole (forces/bonds) ✓	1	<b>ALLOW</b> without hyphen <b>NOT</b> 'ionic-dipole'
<b>Total</b>	<b>25</b>		

Question			Answer	Marks	Guidance
4	(a)	(i)	nitrobenzene ✓	1	<b>ALLOW</b> nitro benzene/ 1-nitrobenzene
		(ii)	water ✓	1	<b>ALLOW</b> H <sub>2</sub> O
		(iii)	molybdenum(VI) oxide ✓	1	<b>NOT</b> molybdenum trioxide or molybdenum(VI) trioxide <b>ALLOW</b> 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	<b>ALLOW</b> 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	<b>ALLOW</b> '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 <b>ALLOW</b> Mo is a heavy metal ✓ Mo is toxic ✓
4	(d)	(i)	nitric acid/HNO <sub>3</sub> as it is accepting a proton/H <sup>+</sup> ✓	1	Both nitric acid <b>AND</b> proton acceptor required for the mark
		(ii)	sulfuric acid... donates/gives/pushes(AW) a proton on to nitric acid <b>OR</b> makes nitric acid act as a base <b>OR</b> acts as an acid with nitric acid / in the mixture <b>OR</b> 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 <b>ALLOW</b> formulae for the acids
		(iii)	acid: H <sub>2</sub> SO <sub>4</sub> base: HSO <sub>4</sub> <sup>-</sup> ✓	1	
		(iv)	HNO <sub>3</sub> → H <sup>+</sup> + NO <sub>3</sub> <sup>-</sup> <b>OR</b> HNO <sub>3</sub> + H <sub>2</sub> O → H <sub>3</sub> O <sup>+</sup> + NO <sub>3</sub> <sup>-</sup> ✓ pH = 1.82 ✓	2	<b>NOT</b> equilibrium sign, <b>NOT</b> [H <sup>+</sup> ] [NO <sub>3</sub> <sup>-</sup> ] <b>ALLOW</b> '(+aq)' on left hand side of top equation <b>IGNORE</b> state symbols <b>ALLOW</b> any value rounding to 1.8 <b>NOT</b> '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 $H^+ = 1.5 \times 10^{-4}$ moles) ✓  pH = 2.30 ✓	2	Correct pH (any number rounding to 2.3) scores both marks without reference to working <b>NOT</b> just a mention of $1.5 \times 10^{-4}$
	(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	<b>QWC</b> 'delocalised' must be spelled correctly to score first mark <b>ALLOW</b> 'delocalized' or derivations such as 'delocalisation'  <b>ALLOW</b> 'six electrons from six carbons' <b>ALLOW</b> '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 <b>IGNORE</b> 'either side of C atoms' <b>ALLOW</b> last two marking points from a labelled diagram
	(f)	(i)	Sn and (conc) HCl ✓  $HNO_2$ (HC//H <sup>+</sup> ) <b>OR</b> NaNO <sub>2</sub> and H <sup>+</sup> /HCl ✓  phenol (or formula) ✓	3	<b>ALLOW</b> names throughout  <b>NOT</b> HNO <sub>3</sub> <b>IGNORE</b> H <sub>2</sub> SO <sub>4</sub> <b>IGNORE</b> 'conc' before HCl  <b>IGNORE</b> NaOH / alkaline conditions other reagents are CON
		(ii)	alkali(ne) conditions / NaOH ✓  low temperature ✓	2	<b>ALLOW</b> 'NaOH/alkaline' if in reagent box from f(i) <b>ALLOW</b> a quoted temperature below 10°C <b>OR</b> reference to ice <b>IGNORE</b> 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. <math>\Delta E = hv/f</math> <b>OR</b> energy <u>gap/difference</u> corresponds to frequency ✓</p> <p>3. benzene absorbs UV (light) <b>AND</b> dyes absorb (visible) light <b>OR</b> benzene's <math>\Delta E</math> corresponds to UV / benzene's <math>\Delta E</math> is too large for it to absorb visible light / visible light cannot excite benzene's electrons <b>AND</b> dye's <math>\Delta E</math> 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 <math>\Delta E</math>/ energy levels closer/ less energy to excite (ora) ✓</p>	6	<p><b>ALLOW</b> 'compound' for 'dye' throughout <b>IGNORE</b> references to d orbitals <b>QWC</b> (link mark): only award second mark if first mark scored <b>ALLOW</b> '<math>E = hv</math>' (no <math>\Delta</math>) <b>only</b> if in context of energy change</p> <p><b>IGNORE</b> 'emits' <b>but</b> 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><b>ALLOW</b> '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' <b>ALLOW</b> 'extended delocalisation' / 'larger [or extended] chromophore' / 'more conjugated'</p>
			<b>Total</b>	<b>30</b>	

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) <b>OR</b> enough energy at room temperature to break imb in formaldehyde/methanal but not methanol ✓	4	<b>NO</b> abbreviations, <b>ALLOW</b> ‘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 <b>ALLOW</b> ‘hydrogen bonds strongest (imb)’ <b>QWC</b> only award fourth marking point if third has been scored									
5	(c)	(i) <table border="1" data-bbox="365 898 1131 1002"> <tbody> <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> </tbody> </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	<b>IGNORE</b> references to catalyst must imply compromise and mention rate (AW) and yield (AW)									
5	(d)	(i) $(K_c = ) [\text{H}_2\text{O}]^2 [\text{HCHO}]^2 / [\text{CH}_3\text{OH}]^2 [\text{O}_2]$ ✓	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 $\Delta S_{\text{tot}}$ always positive ✓ $\Delta S_{\text{tot}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$ ✓ $\Delta S_{\text{sys}}$ positive since more molecules on rhs ✓ $\Delta S_{\text{surr}}$ positive, since $\Delta H$ neg (AW) ✓	4	<b>ALLOW</b> 'entropy increases since more moles on rhs (AW)' for one mark if no others scored <b>ALLOW</b> use of ' $-\Delta H/T$ ' for ' $\Delta S_{\text{surr}}$ ' for 2 <sup>nd</sup> and 4 <sup>th</sup> marking points
	(f) (i)	 <p>one <math>-\text{CH}_2-</math> link correct ✓ both correct ✓</p>	2	<b>ALLOW</b> 'bridge' at 4 position on top two phenol rings <b>ALLOW</b> $-\text{CH}_2-$ straight not just lines joining rings  Other links are CON
	(ii)	condensation because water/small molecule is eliminated (AW)	1	
	(iii)	giant (covalent) <b>OR</b> covalent network ✓	1	<b>IGNORE</b> atomic, lattice <b>NOT</b> ionic, metallic

Question		Answer	Marks	Guidance
	(g) (i)	no O–H / alcohol / hydroxyl ✓ no C=O / carbonyl <b>OR</b> molecule is saturated ✓ contains oxygen/O <b>OR</b> can only have C–O ✓	3	<b>IGNORE</b> wavenumber ranges <b>IGNORE</b> statements about other bonds <b>IGNORE</b> other <b>names</b> of groups containing C=O
	(ii)	triplet – adjacent C has 2 Hs ✓  quartet – adjacent C has 3 Hs ✓	2	for 'triplet' <b>ALLOW</b> any unambiguous identification or range  for 'quartet' <b>ALLOW</b> any unambiguous identification or range <b>IGNORE</b> references to peak height/area <b>ALLOW</b> 'protons' for 'Hs' but <b>NOT</b> 'H'  <b>ALLOW</b> 'environment of 2/3 Hs' or 2/3 neighbouring Hs correctly stated for <i>both</i> peaks as ecf for one mark
	(iii)	$C_2H_5OCH_2OC_2H_5$ ✓ singlet means that $CH_2$ is not attached to a carbon with hydrogens (AW) ✓	2	<b>ACCEPT</b> any correct structural formula <b>ALLOW</b> any unambiguous way of describing this peak <b>ALLOW</b> 'environment of no Hs' or 'no neighbouring Hs' mark separately <b>ALLOW</b> 'no hydrogens on adjacent carbon'
		<b>Total</b>	<b>28</b>	

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