

**GCE**

**Chemistry B (Salters)**

Unit **F335**: Chemistry by Design

Advanced GCE

**Mark Scheme for June 2016**

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Annotations used in RM Assessor:

Annotation	Meaning
✓	correct response – there must be one tick for every one mark awarded
*	incorrect response – These should not be used for every mark lost; just use them in places where it makes your marking clearer.
bod	benefit of the doubt given. Please give a tick as well
nbod	benefit of the doubt <b>not</b> given
ECF	error carried forward
^	information omitted
I	Ignored
SEEN	to be used on any other page where there is a response but no other annotation
BP	indicates a blank page that has been checked.
CON	contradicts a correct response and negates the mark
SF	to draw attention to the significant figures

1. **Subject-specific Marking Instructions** that apply across the whole question paper to be included here.

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

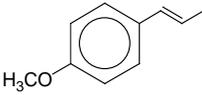
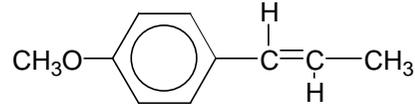
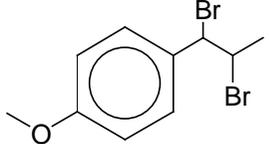
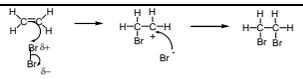
In calculations, rounding errors should not be rewarded, unless the Mark Scheme indicates otherwise. Where a numerical answer is carried forward from a previous part, either the answer in the previous part or the answer left in the calculator may be used.

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.

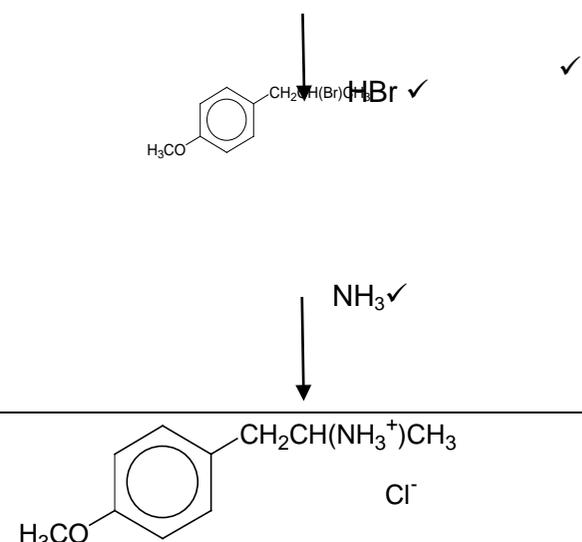
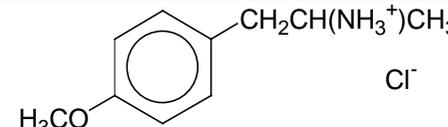
Formulae must have correct brackets and subscripts to score. Element symbols must have small second letters (eg not 'BA'). These errors and the use of a wrong symbol should, if possible, only result in the loss of ONE mark in a part (rather than more marks).

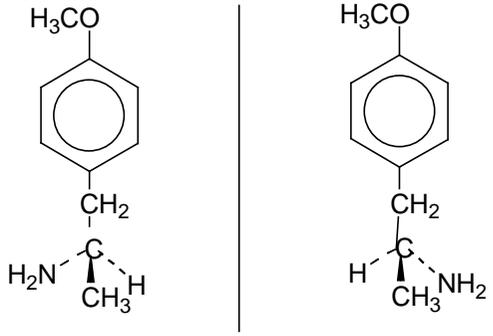
Multiples of equations are acceptable (including halves) unless specified otherwise.

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

-Question			Expected Answers	Marks	Additional Guidance
1	a	i	$C_{10}H_{12}O$	1	<b>ALLOW</b> elements in any order
	a	ii	ether	1	<b>ALLOW</b> methoxy
	a	iii		1	<b>ALLOW</b> any appropriate structural formula or mixture of types of formula. <b>ALLOW</b>  <b>IGNORE</b> small errors in structure if trans is clear must be skeletal (including ether) <b>ALLOW</b> both bromines on same side
	b			1	<b>ALLOW</b> both bromines on same side
	c	i	 <p>bromine attacking <math>C=C</math> including curly arrow and curly arrow and dipole on bromine ✓</p> <p>intermediate formula (could be cyclic) ✓</p> <p><math>Br^-</math> attacking and formula of product ✓</p>	3	curly arrows must start (when projected back) on bond (or – [or lone pair if drawn] on $Br^-$ ) and finish pointing at atoms shown or at the new bond to be formed. <b>IGNORE</b> half arrows. <b>IGNORE</b> partial charges on atoms (or bond) of $C=C$  <b>ALLOW</b> last mark if there is no charge on carbocation

-Question		Expected Answers	Marks	Additional Guidance
	c ii	<p>(First) attack/attraction (AW) is by an electrophile (<math>\text{Br}_2</math>) <b>OR</b> by <math>\text{Br}^+/\text{Br}^{\delta+}</math> ✓</p> <p>(Then) <math>\text{H}_2\text{O}</math>/water can attack (AW) (carbocation)/ can act as nucleophile AW  <b>OR</b> water is not an electrophile ✓</p>	2	<b>ALLOW</b> 'OH' for 'water' but not $\text{OH}^-$
	d	<p>1. Hydrogen bonds are formed between lone pair on O ✓</p> <p>2. and <math>\text{H}^{\delta+}</math>/ H polarised by O-H/ partially(AW) positive hydrogen/H ✓</p> <p>3. Anethole hydrogen bonds (with water) ✓</p> <p>4. hydrogen bonds in water are broken</p> <p>5. hydrogen bonds in water are greater/stronger than imb between anethole and water</p> <p><b>OR</b> more hydrogen bonds broken than made  <b>OR</b> more energy is needed to break bonds than is released in making them</p> <p><b>OR</b> anethole only forms one/two/few hydrogen bonds</p> <p><b>OR</b> rest of anethole can't hydrogen bond (ORA)/ forms id-id ✓</p>	5	<p><b>ALLOW</b> 1., 2. and 3. from diagram reference to hydrogens in anethole forming H-bonds  <b>CONs</b> 2. (1. and 2. can be scored separately)</p> <p>3. and 4. can be scored with some of the alternatives for 5.</p> <p><b>5. ALLOW</b> – for dissolving to occur strength/energy of bonds broken must (roughly) equal strength/energy of bonds made</p> <p><b>IGNORE</b> other attempts at this point if one is correct</p>

-Question		Expected Answers	Marks	Additional Guidance
e	i		3	<p><b>ALLOW</b> any unambiguous formula for intermediate  <b>ALLOW</b> 'NaBr/H<sup>+</sup>' for 'HBr'            Can be names of reagents  <b>IGNORE</b> state symbols on reagents</p> <p><b>ALLOW</b> substitution of HCl/hydrochloric acid with chlorine on intermediate</p> <p>Mark all points separately.</p> <p><b>BUT</b> For 1 mark, allow Br<sub>2</sub> or H<sub>2</sub>O for first reagent followed by corresponding product in intermediate box.</p>
e	ii		1	<p><b>ALLOW</b> 'NH<sub>3</sub>Cl' instead of ions but not 'NH<sub>3</sub>-Cl'  <b>ALLOW</b> N<sup>+</sup>H<sub>3</sub> and (NH<sub>3</sub>)<sup>+</sup>  <b>ALLOW</b> without the chloride</p>

-Question		Expected Answers	Marks	Additional Guidance
e	iii	Drug X has C/chiral centre with four different groups/ asymmetric C ✓  indication of which C and which four groups ✓  no equivalent C in anethole (AW) ✓	3	second marking point can be scored from e(iv) if not scored here <b>ALLOW</b> 'nonsuperimposable mirror image' as alternative to first mpt
e	iv	  one correct 3d structure ✓  mirror image ✓	2	<b>ALLOW</b> ..... instead of ----. <b>ALLOW</b> any unambiguous representation of the 3d structures, but straight lines must not be at 180°. (allow mirror image by ecf) <b>IGNORE</b> incorrect groups when marking mirror image <b>IGNORE</b> non-reflection of NH <sub>2</sub> etc <b>IGNORE</b> bonds to hydrogens rather than C/N  <b>ALLOW</b> correct enantiomers even if not shown as mirror images  <b>ALLOW</b> any indication of organic group even if slightly erroneous and ambiguous attachments
e	v	peak/trough at 3300 - 3500 (cm <sup>-1</sup> )/ one value in the range caused by N-H/NH <sub>2</sub> /amine ✓  no peak at 1620 – 1680/ one value in the range caused by C=C/ alkene ✓	2	Both range and bond/group needed in each case. Award one mark for <b>both</b> ranges without bonds/groups or vice versa
<b>Total</b>			<b>7</b>	

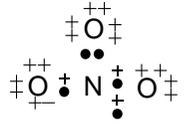
Question			Expected Answers	Marks	Additional guidance
2	a	i	<p style="text-align: center;"><math>\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) \checkmark</math></p> <hr style="width: 20%; margin: auto;"/> <div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center; margin-right: 10px;"> <p>-2258</p> </div> <div style="text-align: center;"> <p><math>\text{CaCl}_2(\text{s}) \checkmark</math></p> <hr style="width: 20%; margin: auto;"/> <p style="margin-top: 20px;"><math>\text{CaCl}_2(\text{aq})/\text{Ca}^{2+}(\text{aq}) + 2\text{Cl}^{-}(\text{aq}) \checkmark</math></p> <hr style="width: 20%; margin: auto;"/> </div> </div> <p><math>\Delta H = -120 \text{ (kJ mol}^{-1}\text{)} \checkmark\checkmark</math></p>	5	<p>allow ecf for omission of '2' on both energy levels</p> <p><b>IGNORE</b> extra energy level for hydration in two steps</p> <p><b>ALLOW</b> lack of plus signs between ions</p> <p>solution level need not be below solid level to score</p> <p>120 scores 1 mark; +120 does not score; +244 (only one hydration of <math>\text{Cl}^{-}</math>) scores 1 mark if solution level is above solid level.</p>
	a	ii	<p>greater charge (density) (of <math>\text{Ca}^{2+}</math>) <math>\checkmark</math></p> <p>stronger attraction/bonds to water molecules (ora for chloride)</p> <p><b>OR</b> more water molecules attracted</p> <p><b>OR</b> stronger/more ion-dipole bonds formed <math>\checkmark</math></p>	2	<p>Mark separately</p> <p><b>IGNORE</b> 'hydration' or 'hydrated'</p>

Question		Expected Answers	Marks	Additional guidance
	<b>b</b>	<p>(one of these needed for second mark)</p> <p>(three of either of these acceptable for first mark)</p> <p>At least three water molecules around ion with 2+ charge (can be shown as  or  with points towards ion) ✓</p> <p>correct formula for at least one water molecule, with bent shapes, <math>\delta+</math> on at least one hydrogen, <math>\delta-</math> on at least one oxygen, with oxygen pointing towards ion ✓</p>	<b>2</b>	<b>ALLOW</b> $\text{Ca}^{2+}$ as ion label, circle not necessary
	<b>c</b>	<p>moles <math>\text{CaCl}_2 = 58.5/111.1</math> <b>or</b> <math>0.527</math> ✓</p> <p>lowering of fpt for <math>\text{CaCl}_2 = 3.7 \times 0.527 \times 1.5 (= 2.9)</math> so fpt is <math>-2.9</math> °C multiplication by 1.5 ✓ rest ✓</p>	<b>3</b>	<p>Allow ecf from mpts 1 to 2</p> <p><b>without reference to working:</b>  <math>-2.9</math> on answer line scores 3  <math>2.9</math> scores 2  <math>-1.9(48....)</math>(or <math>-1.95</math>) scores 2  <math>1.9</math> etc scores 1</p> <p><b>ALLOW</b> slightly different values after checking any intermediate rounding  <b>ALLOW</b> 2 or more significant figures</p>
	<b>d i</b>	$\text{CaCO}_3 + 2\text{NaCl} \rightarrow \text{Na}_2\text{CO}_3 + \text{CaCl}_2$ ✓✓	<b>2</b>	<p>Unbalanced equation with just these species <b>OR</b>  Balanced equation involving <math>\text{CaO}</math>, <math>\text{CO}_2</math> instead of <math>\text{CaCO}_3</math> scores 1 mark  <b>IGNORE</b> state symbols  <b>IGNORE</b> omission of plus signs or arrow if meaning is clear</p>
	<b>d ii</b>	<p>Atom economy 100% <b>AND</b></p> <p>No waste <b>or</b> both products useful ✓</p>	<b>1</b>	

Question		Expected Answers	Marks	Additional guidance
	<b>e</b>	sodium hydrogencarbonate ✓ ammonium chloride ✓	<b>2</b>	allow 'sodium hydrogen carbonate' and (I) after sodium (but not ammonium)
	<b>f</b>	Entropy is a measure of disorder <b>or</b> number of ways of arrangement/distribution of molecules/particles/energy <u>quanta</u> ✓  (more) gas formed has more/higher entropy/disorder/ways of arrangement ✓	<b>2</b>	<b>ALLOW</b> 'disorder' or 'ways of arrangement' for 'entropy' <b>NOT</b> arrangement of a molecule <b>IGNORE</b> 'more molecules formed' needs to be mention of gas formed and it having higher/more entropy
	<b>g</b>	$\Delta S_{\text{sys}} = (+) 215 \text{ (J K}^{-1} \text{ mol}^{-1})$ ✓ $T = \Delta H/\Delta S_{\text{sys}}$ <b>OR</b> $T = 91000/215$ ✓ $T = (+)423 \text{ (K)}$ ✓	<b>3</b>	<b>ALLOW</b> ecf from each step Second marking point can subsume first <b>ALLOW</b> two or more significant figures Negative answers do not score the third marking point even if they follow by ecf. If 423 shows in working but 424 given, mark can be awarded.  Correct answer on answer line scores 3 marks

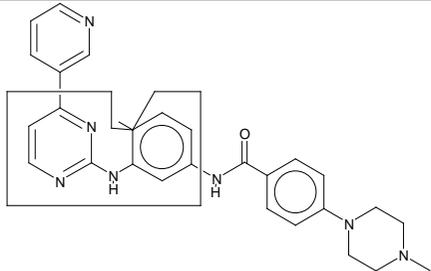
Question		Expected Answers	Marks	Additional guidance
	<b>h i</b>	$\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+$ <b>OR</b> $\text{NH}_4^+ + \text{H}_2\text{O} \rightleftharpoons \text{NH}_3 + \text{H}_3\text{O}^+$	<b>1</b>	If ss are present they must be (aq) [or (l) for water]
	<b>h ii</b>	$[\text{H}^+] = \sqrt{(5.6 \times 10^{-10} \times 0.01)}$ <b>or</b> $2.37 \times 10^{-6} \text{ (mol dm}^{-3}\text{)}$ ✓ pH = 5.6(3) ✓	<b>2</b>	<b>ALLOW</b> 'H <sup>+</sup> = ' for '[H <sup>+</sup> ] = ' Ecf for second mark for a [H <sup>+</sup> ] (or H <sup>+</sup> ) value larger than $1 \times 10^{-7}$ and smaller than $1 \times 10^{-3}$ . Must be to at least one decimal place Correct answer scores both marks without working
	<b>h iii</b>	1. H <sup>+</sup> added ✓ 2. eqm <u>position</u> moves to left ✓  3. large NH <sub>3</sub> (concentration) ✓ 4. pH constant/little change ✓	<b>4</b>	1. <b>IGNORE</b> 'acid added' 2. This mark cannot be scored if it does not match the equation in (i) – allow ecf from equation in (i) but it must contain H <sup>+</sup> . <b>QWC</b> only allow 2nd mpt if 1st scored or it says 'acid added'  3. and 4. mark separately
	<b>h iv</b>	Use of $[\text{H}^+] = K_a \times [\text{NH}_4^+]/[\text{NH}_3]$ <b>or</b> $\text{pH} = \text{p}K_a - \log [\text{NH}_4^+]/[\text{NH}_3]$ <b>or</b> $[\text{H}^+] = 2.8 \times 10^{-10} \text{ (mol dm}^{-3}\text{)}$ ✓ pH = 9.55/ 9.6 ✓	<b>2</b>	Mark this part without reference to h(i). Correct answer scores 2 marks without reference to working; 8.95/ 9.0 (ratio wrong way up) scores 1 mark without reference to working; no other ecf.  must be at least one decimal place
		<b>Total</b>	<b>31</b>	

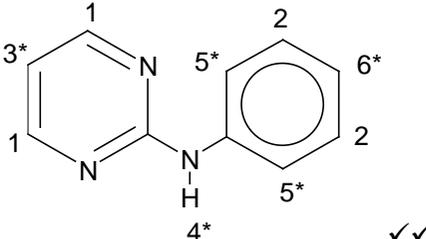
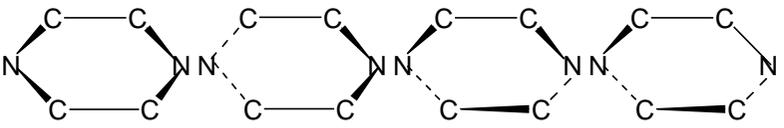
Question	Expected answer	Mark	Additional Guidance
3	a i	1	<b>ALLOW</b> 'particles' or 'molecules' or 'species' for 'moles'
	a ii	1	
	a iii	2	<b>ALLOW</b> on its own mark separately
	b i	2	<b>ALLOW</b> same number of molecules/moles/amounts <b>IGNORE</b> CO and H <sub>2</sub> O are 1:1  <b>ALLOW</b> 'virtually all CO converted/reacted'
	b ii	3	scores if $(1.5 \times 10^{-3})^2$ seen in working.  Correct answer to any sf scores 2 and correct answer to 1sf scores 3 without reference to working. <b>ALLOW</b> $10 \times 10^{-4}$ Any answer to 1sf scores last mark separately.
	b iii	1	Answer alone scores mark  <b>ALLOW</b> 1 or more sf
	c	3	Must have ideas of particles and collision to score by first alternative. <b>ALLOW</b> 'successful collision' for 'react when they collide' <b>IGNORE</b> 'catalyst lowers $E_a$ '.  Must mention collisions

Question		Expected answer	Mark	Additional Guidance
d	i	 <p>five electrons from N ✓; completely correct ✓</p> <p>+5 ✓</p>	3	<p>oxygen atoms can be in any position; the left-hand one (here) can be with a minus, as shown or an extra cross or another symbol.</p> <p><b>IGNORE</b> brackets and minus signs</p> <p>Expansion of the octet does not score second mark</p> <p><b>NOT</b> 5+ or 5</p>
d	ii	<p><math>\text{NH}_4\text{NO}_3 \rightarrow 2\text{H}_2\text{O} + \text{N}_2\text{O}</math> ✓</p> <p>dinitrogen (mon)oxide <b>or</b> (di)nitrogen(I) (mon)oxide <b>AND</b> colourless (gas) ✓</p>	2	<p><b>IGNORE</b> state symbols</p> <p><b>ALLOW</b> halves and multiples</p> <p><b>IGNORE</b> gaps in name</p> <p>second mark depends on <math>\text{N}_2\text{O}</math> being formed</p> <p><b>ALLOW</b> ecf from NO or <math>\text{NO}_2</math> formed in the equation.</p>
			18	

Question			Expected Answers	Marks	Additional guidance
4	a	i	+3✓ $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$ ✓	2	<b>NOT</b> 3+ or 3 <b>ALLOW</b> capital letters but numbers must be superscripts. <b>ALLOW</b> ecf for $Fe^{2+}$ only ( $3d^6$ ) <b>ALLOW</b> repetition of ' $1s^2 2s^2$ ' <b>IGNORE</b> $4s^0$
4	a	ii	Amount of water = $0.216/18 = 0.012$ mol ✓  (Mass of anhydrous = $1.066 = 0.012$ mol so) $n = 1$ ✓	2	Mark separately $n = 1$ on the answer line (without first marking point) scores second mark only
	a	iii	Amount Fe = $0.012$ mol = $0.670$ g Mass O = $1.066 - 0.670 - 0.140 = 0.256$ ✓ Amount O = $0.256/16 = 0.016$ , $y = 4$ ✓ <b>OR</b> $1$ mole $FeO(OH) \rightarrow \frac{1}{3}$ mole $Fe_3O_x$ so $0.012$ mol $\rightarrow 0.004$ mol $0.004$ moles have a mass of $(1.066 - 0.14)g = 0.926g$ ✓ $1$ mole weighs $0.926/0.004 = 231.5g$ Mass of the 3 Fe atoms subtracted = $64g$ so 4 moles of O $y = 4$ ✓	2	working must be checked look for mass O = $0.256$ or <u>0.004 moles</u> weigh $0.926g$ for 1 mark  $y = 4$ without coherent working scores 1
	b	i	Yellow/green (or 'yellow/green' or orange) because: it reflects this/ reflects between red and blue	1	must say 'reflects' (or a derived word) or 'maximum reflectance' and give colour to score
	b	ii	(3)d energy levels/subshells/orbitals split (by ligands) ✓ electrons excited (or move) to higher energy level/shell/orbital or be excited/move up from lower level ✓  light absorbed <b>and</b> $\Delta E = hv$ or $hf$ ✓  complementary frequency/colour/wavelength <u>reflected/transmitted</u> ✓	4	<b>IGNORE</b> 'D'  <b>ALLOW</b> 'frequency <u>proportional</u> to energy gap/difference' for ' $\Delta E = hv$ ' (or $E = hv$ if 'energy gap/difference' is implied). (or 'photon energy $hv$ ')  <b>ALLOW</b> 'complimentary' or 'frequencies not absorbed are <u>reflected/transmitted</u> '. <b>IGNORE</b> 'emitted' but any indication of light being given out when electrons fall <b>CONs</b> last marking point.

Question		Expected Answers	Marks	Additional guidance
	<b>c</b>	<p>Spectrum is coloured lines ✓ on dark/black (background) ✓</p> <p>lines/spectrum/frequencies are unique/characteristic/specific to an element/Fe ✓</p> <p>because energy gaps are unique <b>OR</b> compare with known data AW ✓</p>	<b>4</b>	<p><b>IGNORE</b> atom, compound and molecule</p> <p>must imply 'gaps between levels' not just 'levels' to score</p>
	<b>d i</b>	<p>ester ✓; reaction with 3KOH and 3 salts formed ✓ propane-1,2,3-triol ✓</p>	<b>3</b>	<p><b>ALLOW</b> any unambiguous structural formulae to score eg <math>\text{-OOCR}</math> etc for esters</p> <p><b>ALLOW</b> with <math>\text{OH}^-</math> as reactant and carboxylate ion as product, without <math>\text{K}^+</math> spectator ion</p> <p><b>ALLOW</b> 'OK' but not 'O-K' for 'O<sup>-</sup>K<sup>+</sup>'</p> <p>Give one mark for ester and triol structures swapped as reactant and product</p>
	<b>d ii</b>		<b>1</b>	<b>ALLOW</b> 'RC' without bond
	<b>d iii</b>	methanol and conc sulfuric acid/ conc hydrochloric acid ✓	<b>1</b>	<b>ALLOW</b> formulae <b>IGNORE</b> carboxylic acid if mentioned
	<b>e</b>	<p>nitrogen/ argon other named noble gas ✓ high boiling point/ involatile/ non-volatile liquid ✓ some time unit ✓</p>	<b>3</b>	<b>ALLOW</b> formulae
			<b>23</b>	

Question		Expected Answers	Marks	Additional guidance
5	a	the N atoms hydrogen bond (to water)	1	
	b	i	1	<b>ALLOW</b> lines cutting bonds to do so anywhere on the bond.
				
	b	ii	4	<p><b>QWC:</b> word 'substrate' must be used and spelled correctly to score third marking point.</p> <p>This must be comparative can score first mark here</p>
	c	i	2	<p><b>ALLOW</b> formulae. 'Conc'/'concentrated'/'c.' must be mentioned once somewhere 'reflux' is <b>CON</b> Mark separately</p>
	c	ii	1	<p><b>IGNORE</b> formulae <b>IGNORE</b> 'hydrogen chloride'</p>
	c	iii	3	<p><b>ALLOW</b> <math>C_6H_5CO-O-COC_6H_5</math> <b>ALLOW</b> molecular formulae and any type of structural formula ecf: Name can match formula but only for benzoic anhydride or benzoic acid.</p>

Question		Expected Answers	Marks	Additional guidance
d	i	$C_{10}H_9N_3$	1	<b>ALLOW</b> elements in any order
d	ii		2	Asterisked numbers can be transposed two marks for completely correct; <i>one mark if:</i> '5' and '5' shown as the same ( <b>NOT</b> 1) and different from others on right-hand ring and '4' shown as a unique no. <b>OR</b> all correct except for the omission of a number on the NH <b>ALLOW</b> '4' above N
e		<p>109 (<sup>0</sup>) ✓            pyramidal ✓</p> <p>4 groups/pairs of electrons/ 4 areas of electron density ✓</p> <p>(electrons) repel and get as far away from each other as possible ✓</p> <p>diagram of either chair or boat or 3D structure (wedges and dashes) ✓            eg award the mark to:</p> 	5	<b>ALLOW</b> 105 – 110 <b>IGNORE</b> 'trigonal', 'triangular' and 'tetrahedral' no ecf from angle on 3 <sup>rd</sup> mark. <b>QWC</b> Do not award third mark if angle incorrect <b>ALLOW</b> 'minimise repulsion' <b>IGNORE</b> 'repel as much as possible'
f		<p>Each atom in the ring contributes one electron ✓</p> <p>electrons delocalised ✓</p> <p>two rings of electrons above and below ring (of atoms)/ plane/atoms/ molecule ✓</p>	3	<b>ALLOW</b> N atoms contribute two/lone pair electrons must make it clear there are two rings

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