OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry B (Salters)

Advanced GCE

Unit **F335:** Chemistry by Design

Mark Scheme for January 2011

Oxford Cambridge and RSA Examinations

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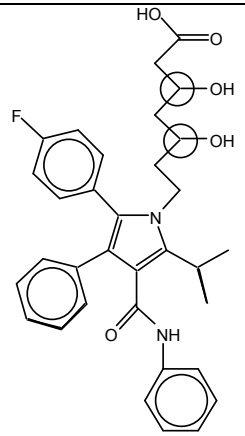
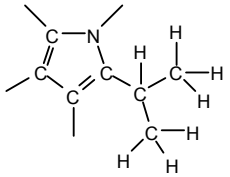
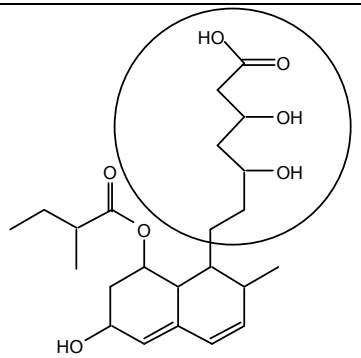
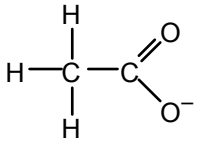
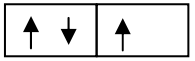
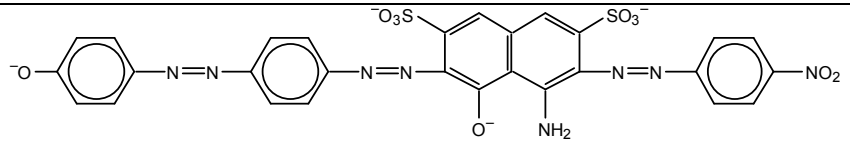
MARK SCHEME

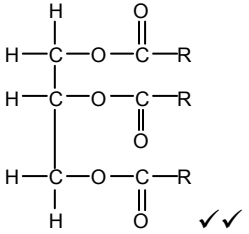
Question			Answer	Mark	Guidance
1	(a)	(i)	ester ✓	1	
1	(a)	(ii)	(secondary) alcohol/hydroxy(l) **OR** carboxylic acid/carboxyl ✓	1	**ALLOW** alkene /C=C/carbon-carbon double bond **NOT** 'carboxylic' or 'acid'
1	(b)	(i)	 ✓	1	one mark for both **DO NOT ALLOW** if any extra atoms/groups are circled (unless it is clearly the pharmacophore that is being circled)
1	(b)	(ii)	(object and) mirror image ✓ non superimposable (AW) ✓	2	mark separately must imply that they will not fit on top of each other
1	(c)		 right hand three carbons correct ✓ ring correct ✓	2	mark separately **IGNORE** attachments on 'unattached bonds' must be **full** structural

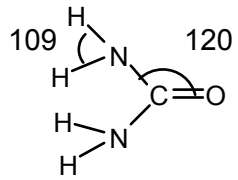
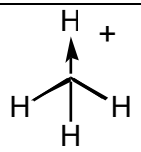
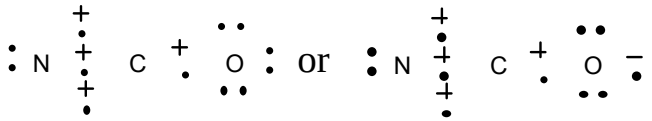
Question			Answer	Mark	Guidance
1	(d)	(i)	the part of the molecule that *either* binds/bonds/fits to a receptor/enzyme/active site *or* is responsible for the medicinal/pharmacological action/ acts as the drug (AW) ✓	1	**NOT** 'functional group' **NOT** 'part of the drug' must make it clear that it is 'part' and 'of molecule' must say 'part of molecule' (AW) **AND** then the *either/or* **ALLOW** produces biological response/biologically active **NOT** just 'activity'
1	(d)	(ii)	 ✓	1	circle can cut carbon chain anywhere from bond shown to bond below bottom –OH **anything else circled is CON** **ALLOW** circle (oval) on wrong molecule
1	(d)	(iii)	(statin) bonds to <u>active site</u> of enzyme ✓ blocking active site/ enzyme/ receptor ✓ <u>substrate</u> cannot bond **OR** (statin) bonds more strongly than substrate **OR** fewer active sites **OR** reduces enzyme activity (AW) ✓	3	'Statin' must be implied **ALLOW** binds/fits/forms complex/fix **ALLOW** 'cannot be broken down'/ 'binds permanently'/ does not react **ALLOW** 'bind' or 'fit' **NOT** 'cholesterol' for 'substrate' **NOT** 'stops enzyme working' or 'inhibits enzyme'

Question			Answer	Mark	Guidance
1	(e)			4	**Please annotate with ticks where the marks are scored**
			show that a compound prevented cholesterol synthesis /has medicinal properties ✓		**ALLOW** 'does it work?'/ does it give desired effect? **ALLOW** 'identify (lead) compound'
			clinical trials ✓		**ALLOW** animal/ethical testing or 'is it safe?'/'check for side-effects' **NOT** just 'trials' alone
			analyse/work out structure/ identify pharmacophore✓		**ALLOW** 'computer modelling'
			synthesise (similar molecules) ✓		**NOT** just 'synthetic' (in question) **ALLOW** 'making' AW
					ACCEPT marking points in any order **IGNORE** 'is it better than other drugs?'
			Total	**16**	

Question			Answer	Mark	Guidance
2	(a)		 ✓	1	**ALLOW** shown as delocalised structure **ALLOW** as part of a complex (even if detail of complex is not quite correct)
2	(b)	(i)	+3 ✓	1	**ALLOW** 3+
2	(b)	(ii)	copper(II) arsenate(III) ✓	1	**IGNORE** gaps between words and numbers **ALLOW** ecf from a positive number in b(i)
2	(c)	(i)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ ✓	1	**ALLOW** $4s^0$ in addition
2	(c)	(ii)	 ✓	1	to score there must be two electrons with opposite arrows (including 'half-arrows') in one box and one electron in the other **ALLOW** ecf from **(i)** for d^7, d^8 and d^{10}
2	(c)	(iii)	<u>electrons</u> promoted / excited ✓ light absorbed ✓ *QWC: only award this mpt if 1st mpt scored* frequency/wavelength depends on energy gap/ excitation energy **OR** (∆)E = hν ✓ ligands affect size of gap/ splitting/ (∆)E/excitation energy ✓ <u>complementary</u> colour transmitted/ reflected ✓	5	**Please annotate with ticks where the marks are scored** 'dropping down' connected with light **CON**s 2nd mpt and loses 5th mpt. Others can be scored **ALLOW** 'complimentary' **NOT '**emitted'

Question			Answer	Mark	Guidance
2	(d)		one set of energy levels (at least three with upper gap smaller than lower gap – ignore higher gaps if >3 lines) ✓ second set with different separations – one labelled arsenic and/or one labelled copper ✓ at least two downward arrows on one set ✓ at least one arrow on second set labelled as being of a different frequency/ different energy gap **OR** indication that different lengths correspond to different frequencies ✓	4	**NOT** 'circular' diagrams for this mark but can score for other marks Just two levels (at different separation from first set) will score this mark (ignore separation) If upwards arrows are shown as well, the downward arrows must be labelled as 'emission' or 'lines' can be in words rather than an arrow label
2	(e)	(i)	delocalised electrons / conjugated electrons / conjugated system / pi system ✓	1	**ALLOW** (possesses a) chromophore **IGNORE** description of where chromophore etc is
2	(e)	(ii)	 O^- twice ✓ SO_3^- twice ✓ rest unchanged ✓	3	wrong changes to the rest of the molecule (apart from OH's and SO_3H's) lose the last mark only **ALLOW** Na^+ with anions **IGNORE** wrong attachments
2	(f)	(i)	HNO_3 / nitric acid / nitric(V) acid ✓	1	**IGNORE** concentration **IGNORE** sulfuric/sulphuric
2	(f)	(ii)	coupling ✓	1	**IGNORE** qualifications of 'coupling'
2	(g)	(i)	sulfonic acid ✓	1	**ALLOW** sulphonic acid **ALLOW** hydrogen sulfonate

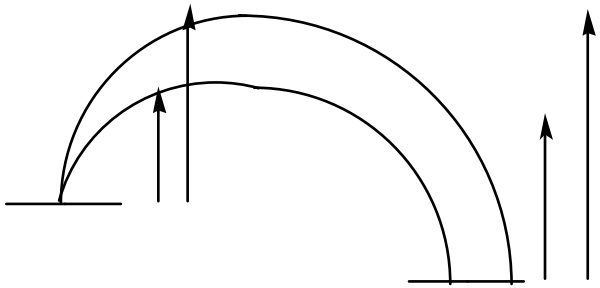
Question			Answer	Mark	Guidance
2	(g)	(ii)	electrostatic / ion-ion / ionic bonds broken ✓ ion-dipole bonds formed ✓ hydrogen bonds (in water) broken ✓ similar strength (between bonds broken and made) AW ✓ QWC *both* 'hydrogen bonds' and 'ion-dipole bonds' must be correctly spelled to score their marks	4	use of 'molecules' or 'atoms' to describe ionic substance **CON**s first mark **IGNORE** 'hydrogen bonds between ion and water' **IGNORE** 'ionic dipole' **ALLOW** 'bonds made are stronger than bonds broken' or 'energy released' AW **ALLOW** 'energy required to break bonds is less than energy required to make bonds' **IGNORE** 'intermolecular forces'
2	(h)	(i)	 ✓✓	2	carbon backbone with Os and Hs correctly attached ✓ rest correct ✓ **ALLOW** ester reversed for one mark overall
2	(h)	(ii)	carbon-carbon double bonds / C=C / alkene groups ✓	1	**ALLOW** 'double bond in hydrocarbon chain'
			Total	28	

Question			Answer	Mark	Guidance
3	(a)	(i)	 structure ✓ 120±2 ✓ 104 – 120 ✓	3	angles of actual bonds in structure immaterial any bond angle around each atom can be indicated Bond angles must start and finish on bonds (allow ecf if bond angles 'fall short' twice) (large range for the nitrogen bond to allow for delocalisation)
3	(a)	(ii)	 ✓	1	bond angles immaterial dative bond to any hydrogen (arrow or labelled) **IGNORE** presence or absence of plus charge **IGNORE** dot-cross diagram **ALLOW** 3-dimensional diagram
3	(a)	(iii)	 bonding on C and N correct ✓ arrangement of electrons on oxygen ✓	2	**IGNORE** any negative charges shown **ALLOW** other symbols for electrons **ALLOW** • x for • / x
3	(b)		(both organics and inorganics) contain the same elements ✓	1	**IGNORE** 'same atoms'
3	(c)		(Mr = 60.0; % = 28.0 x 100/60.0 =) 46.7% ✓ any shown calculation resulting in 3sf answer ✓	2	**ALLOW** two or more sf for first mark [46.6666667] 46.6 scores one mark
3	(d)	(i)	Idea of RHS – LHS ✓ ((2x192) – (3x130) – 192 =) –198 ✓	2	e.g. '192 – 130 – 192' – 198 on its own scores two marks **DO NOT ALLOW** ecf on second mpt, except 1 for +198 (sign must be there)

Question			Answer	Mark	Guidance
3	(d)	(ii)	fewer moles on right hand side ora✓ fewer ways of arranging (fewer molecules) / less disorder AW ✓	2	**IGNORE** 'fewer products' **ALLOW** 'fewer particles on right' **ALLOW** 'less' for 'fewer'
3	(d)	(iii)	ΔS_{tot} = (answer to 3di) + 92000/298 (= -198 + 309) ✓ correct evaluation with correct sign given ✓	2	**ALLOW** more decimal places, provided rounding is correct +111 scores both marks; 111 scores one mark ΔS_{tot} = (answer to 3di) + 920/298 plus evaluation (with correct sign given) scores second mark only –197.7 (or equivalent – wrongly using 92/298) scores 1 –507 (or equivalent – wrongly using –309) scores 1 no other ecf
3	(d)	(iv)	ΔS_{tot} is: more negative / less positive / lower ✓ecf less likely to occur / equilibrium lies further to left / decreased yield / fewer products ✓ecf	2	ecf from incorrect values above no ecf from wrong first statement – mark separately **IGNORE** 'would not take place (when ΔS_{tot} negative)'
3	(e)	(i)	–3 ✓ +5 ✓	2	**ALLOW** one mark only for two correct numbers *followed* by correct signs
3	(e)	(ii)	$NH_3 + 3H_2O \rightarrow HNO_3 + 8e^- + 8H^+$ **OR** $NH_3 + 3H_2O \rightarrow NO_3^- + 8e^- + 9H^+$ ✓✓	2	$NH_3 \rightarrow HNO_3 + 8e^-$ scores one mark whatever else is there there are no other ways of scoring one mark
3	(e)	(iii)	$NH_3 + HNO_3 \rightarrow NH_4NO_3$ ✓ 100% ✓	2	**ALLOW** $NH_4^+ NO_3^-$ no ecf second mark depends on first

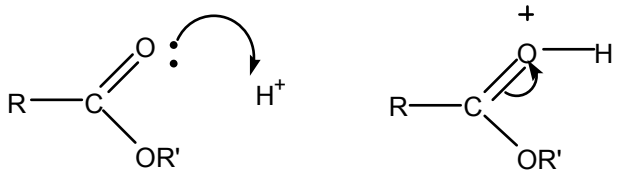
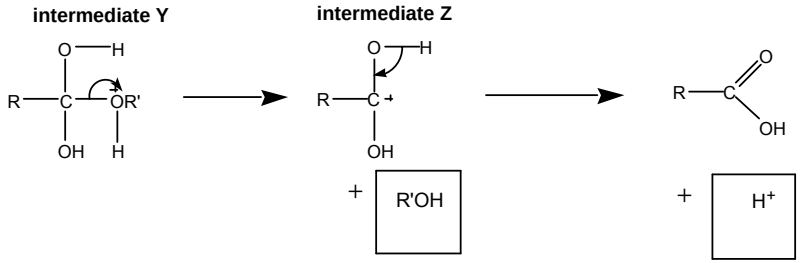
Question			Answer	Mark	Guidance
3	(e)	(iv)	ammonia is alkaline / toxic **OR** nitric acid is acidic / corrosive / toxic / powerfully oxidising **OR** ammonium nitrate is explosive ✓	1	hazardous reagent must be named or given formula **AND** correct hazard must be stated
			Total	24	

Question			Answer	Mark	Guidance
4	(a)		CH_3COOH (or more displayed) ✓	1	**ALLOW** 'ethanoic acid' or molecular formula **IGNORE** other products
4	(b)		105 - 110 ✓ four groups/pairs of electrons **OR** four areas of electron density ✓ (groups/pairs of) electrons **OR** areas of electron density **OR** bonds repel ✓ (groups/pairs of) electrons **OR** areas of electron density **OR** bonds get as far apart as possible / repulsion minimised / (repel) as far as possible ✓	4	**Please annotate with ticks where the marks are scored** mark separately **ALLOW** 'four points of electrons' **ALLOW** 'two lone pairs and two <u>bonding pairs</u>' No ecf between first and second points **ALLOW** 'move apart (AW) to minimise repulsion' for last two mpts **NOT '**repel as much as possible' (do not award 4th mpt)
4	(c)	(i)	hydrogencarbonate ✓	1	**ALLOW** hydrogencarbonate(IV) **IGNORE** gaps
4	(c)	(ii)	none **OR** catalysts do not affect equilibrium positions ✓ catalysts / enzymes / carbonic anhydrase / it: speed up forward and backward / both reactions (equally) OR affect rate of reaction <u>only</u> / speed up reaction <u>only</u> OR speed up achievement of equilibrium AW ✓	2	Mark separately

Question			Answer	Mark	Guidance
4	(c)	(iii)	 product and reactant <u>lines</u> ✓ catalysed and uncatalysed lines ✓ indication that enthalpy change of activation is lowered for both forward and back reaction ✓ One correct arrow (single or double ended) labelled Ea / 'activation enthalpy' ✓	4	**Please annotate with ticks where the marks are scored** **ALLOW** endo or exothermic or 'level' **IGNORE** labels for energy levels (need not be labelled) **ALLOW** catalysed line with intermediate indication can be by label or by note incorrect arrows **CON** correct arrows
4	(d)	(i)	(lower [CO_2]) moves equm (position) to left ✓ pH rises ✓	2	**IGNORE** 'less acidic' / 'more alkaline' / 'less H^+' Mark separately – NO ecf from 1st mpt
4	(d)	(ii)	(equm) change happens (much) more slowly / does not happen without catalyst / pH does not change (much) / changes slowly ✓	1	**IGNORE** references to equilibrium position **ALLOW** 'not speeded up'

Question			Answer	Mark	Guidance
4	(e)		$([H^+]) = 4.0 \times 10^{-8}$ ✓ $(3.981071706 \times 10^{-8})$ $[CO_2] = 4.0 \times 10^{-8} \times 2.5 \times 10^{-2} / 4.5 \times 10^{-7}$ $= 2.2 \times 10^{-3}$ ✓ ecf (Full calculator answer gives $2.211706503 \times 10^{-3}$ 4.0×10^{-8} gives $2.222.... \times 10^{-3}$ 3.98×10^{-6} gives $2.2111..... \times 10^{-3}$)	2	For ecf , must have at least 'H^+ =' correct answer with no working scores 2 **ALLOW** 2 or more sf for first or second marks but rounding must be correct (eg **NOT** 3.9×10^{-8}) ecf for second mark **EITHER** on what is written **OR** figures which might reasonably be on a calculator
4	(f)		resists pH change AW ✓ when acid/alkali added ✓ in small quantities ✓ <u>equilibrium</u> moves to left when acid added [ORA for alkali] ✓ removing acid / H^+ [ORA for alkali] ✓ large concentration of HCO_3^- ✓	6	third mark depends on second other marks independent **IGNORE** reference to general HA equation **ALLOW** 'HCO_3^- reacts with H^+' **NOT** just 'maintains pH' **IGNORE** references to large concentrations of CO_2 or 'sink'
4	(g)		two from: ✓ ✓ increasing photosynthesis / planting <u>more trees</u> capture and storage in the oceans / under the sea capture and storage in (former) oil / gas wells / <u>porous</u> rock	2	**IGNORE** ways of generating less CO_2 **NOT** just 'capture and storage' **NOT** 'under sea bed'
			Total	25	

Question			Answer	Mark	Guidance
5	(a)		methyl butanoate ✓	1	**NOT** 'butanate'
5	(b)		HCOOH ✓ $CH_3CH(CH_3)CH_2OH$ ✓ or more displayed methanoic acid ✓ 2-methylpropan-1-ol ✓	4	**IGNORE** commas, hyphens and gaps **IGNORE** ambiguous attachments in formulae mark names and formulae separately but no ecf between them
5	(c)		*3 main marks shown plus any three from bracketed marks:* MS – M_r ✓ [different fragments, with one suggestion of a different fragment for one ester ✓] IR – bonds / functional groups ✓ [fingerprint, compared with known values ✓] [The esters both have same Mr (allow ecf from above) and bonds ✓] nmr – environments of protons/hydrogen atoms (ignore H^+) ✓ [ratio of areas / intensities 6:1:2:1 or 3:2:2:3 ✓] [different shifts (with one correct detail of one ester) ✓] [splitting (with one correct detail of one ester) ✓]	6	**Please annotate with ticks where the marks are scored** **ALLOW** '(relative) molecular/formula mass' or 'molar mass', **NOT** just 'mass' fragments must have formulae but need not have charge 'environment' mark can be inferred from detail of nmr given later or one comment on ratio of areas,eg note of six protons in one environment, in A only, will score indication of twice as many protons (eg) at 0.7 – 1.6 will score B has 2.0 – 2.7; A has 9.4 – 10.0 *Last four bracketed marks all contain QWC link* **IGNORE** inaccurate statements unless they actively **CON** a mark

Question			Answer	Mark	Guidance
5	(d)	(i)	 ✓✓ 1 each	2	First arrow must start on lone pair (it must be within 'one lone pair width'). It goes either to hydrogen or points to bond between O and H. Extra arrows **CON** any correct arrows on the same molecule **IGNORE** arrows on right-hand two molecules Second arrow goes from double bond to oxygen. (line and arrow must extrapolate to touch the correct place) 'half arrows' are not rewarded the first time they occur but can then be awarded by ecf (through into d(iii))
5	(d)	(ii)	water ✓	1	**ALLOW** H_2O
5	(d)	(iii)	 arrow on Y ✓ arrow on Z ✓ R'OH ✓ H^+ ✓	4	First arrow must go from bond to oxygen Second arrow must go from bond to bond (same extrapolation rules as above for both) **ALLOW** arrows from O-H bond to O and then from O to O-C bond Extra arrows **CON** any correct arrows on the same molecule **IGNORE** wrong attachments in R'OH **ALLOW** ROH for R'OH
5	(e)	(i)	$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ ✓	1	**ALLOW** $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$ **ALLOW** $C_2H_4O_2 \rightleftharpoons C_2H_3O_2^- + H^+$ Must have equilibrium sign **IGNORE** state symbols

Question			Answer	Mark	Guidance
5	(e)	(ii)	($[H^+] = [CH_3COO^-]$ =) 6.3×10^{-4} ✓✓	2	**ALLOW** more sf [6.3095734] If answer is incorrect: **ALLOW** one mark for $[H^+] = [CH_3COO^-]$ **OR** $H^+ = 6.3 \times 10^{-4}$ (or more sf)
5	(f)	(i)	titration with alkali / base / named strong alkali ✓ standard / known concentration ✓	2	**IGNORE** measuring out initial acid
5	(f)	(ii)	0.70 ✓	1	**ALLOW** 0.7
5	(f)	(iii)	Correct Kc expression, [RCOOR] x [H_2O]/ [ROH] x [RCOOH] (answer from (f)(ii) squared) / $0.4(0)^2$ (or correctly evaluated) ✓ Correct evaluation of a given expression with (answer from (f)(ii) squared) on top and any two numbers on the bottom ✓ (=3.1)	3	First mark can be awarded if second is correct 3.0625 (to one or more sf) scores 3 marks without reference to working Correct evaluation of mpt 2 scores 3 marks without reference to working any units quoted **CON** third mark
			Total	27	

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