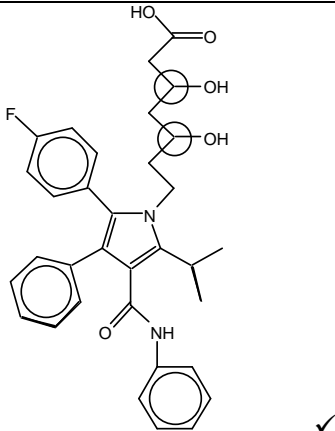
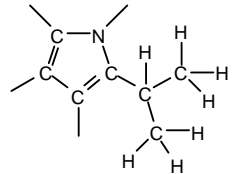
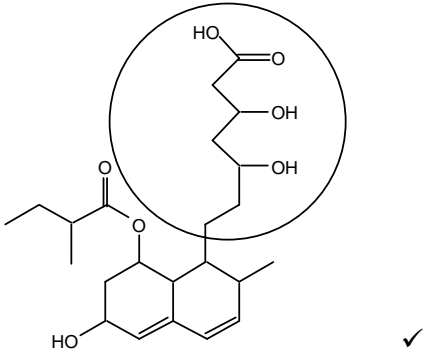
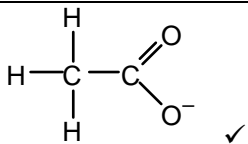



MARK SCHEME

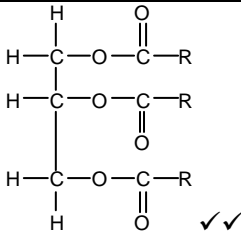
Question			Answer	Mark	Guidance
1	(a)	(i)	ester ✓	1	
1	(a)	(ii)	(secondary) alcohol/hydroxy(l) OR carboxylic acid/carboxyl ✓	1	ALLOW alkene /C=C/carbon-carbon double bond NOT 'carboxylic' or 'acid'
1	(b)	(i)		1	one mark for both DO NOT ALLOW if any extra atoms/groups are circled (unless it is clearly 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

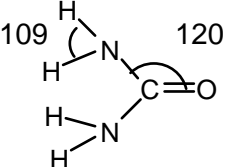
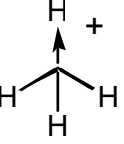
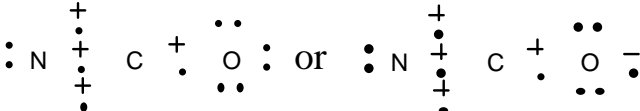
Question			Answer	Mark	Guidance
1	(d)	(i)	the part of the molecule that <i>either</i> binds/bonds/fits to a receptor/enzyme/active site or is responsible for the medicinal/pharmacological action/ acts as the drug (AW) ✓	1	NOT 'functional group' NOT 'part of the drug' must make it clear that it is 'part' and 'of molecule' must say 'part of molecule' (AW) AND then the <i>either/or</i> 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)		<p>show that a compound prevented cholesterol synthesis /has medicinal properties ✓</p> <p>clinical trials ✓</p> <p>analyse/work out structure/ identify pharmacophore✓</p> <p>synthesise (similar molecules) ✓</p>	4	<p>Please annotate with ticks where the marks are scored</p> <p>ALLOW 'does it work?'/ does it give desired effect? ALLOW 'identify (lead) compound'</p> <p>ALLOW animal/ethical testing or 'is it safe?'/check for side-effects' NOT just 'trials' alone</p> <p>ALLOW 'computer modelling'</p> <p>NOT just 'synthetic' (in question) ALLOW 'making' AW</p> <p>ACCEPT marking points in any order IGNORE 'is it better than other drugs?'</p>
			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 ✓ <i>QWC: only award this mpt if 1st mpt scored</i> frequency/wavelength depends on energy gap/ excitation energy OR $(\Delta)E = h\nu$ ✓ ligands affect size of gap/ splitting/ $(\Delta)E$ /excitation energy ✓ <u>complementary</u> colour transmitted/ reflected ✓	5	Please annotate with ticks where the marks are scored 'dropping down' connected with light CONs 2nd mpt and loses 5th mpt. Others can be scored ALLOW 'complimentary' NOT 'emitted'

Question			Answer	Mark	Guidance
2	(d)		<p>one set of energy levels (at least three with upper gap smaller than lower gap – ignore higher gaps if >3 lines) ✓</p> <p>second set with different separations – one labelled arsenic and/or one labelled copper ✓</p> <p>at least two downward arrows on one set ✓</p> <p>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 ✓</p>	4	<p>NOT ‘circular’ diagrams for this mark but can score for other marks</p> <p>Just two levels (at different separation from first set) will score this mark (ignore separation)</p> <p>If upwards arrows are shown as well, the downward arrows must be labelled as ‘emission’ or ‘lines’</p> <p>can be in words rather than an arrow label</p>
2	(e)	(i)	delocalised electrons / conjugated electrons / conjugated system / pi system ✓	1	<p>ALLOW (possesses a) chromophore IGNORE description of where chromophore etc is</p>
2	(e)	(ii)	<p>O⁻ twice ✓ SO₃⁻ twice ✓ rest unchanged ✓</p>	3	<p>wrong changes to the rest of the molecule (apart from OH's and SO₃H's) lose the last mark only</p> <p>ALLOW Na⁺ with anions IGNORE wrong attachments</p>
2	(f)	(i)	HNO ₃ / nitric acid / nitric(V) acid ✓	1	<p>IGNORE concentration IGNORE sulfuric/sulphuric</p>
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)	<p>electrostatic / ion-ion / ionic bonds broken ✓</p> <p>ion-dipole bonds formed ✓</p> <p>hydrogen bonds (in water) broken ✓</p> <p>similar strength (between bonds broken and made) AW ✓</p> <p>QWC <i>both</i> 'hydrogen bonds' and 'ion-dipole bonds' must be correctly spelled to score their marks</p>	4	<p>use of 'molecules' or 'atoms' to describe ionic substance CONs first mark IGNORE 'hydrogen bonds between ion and water' IGNORE 'ionic dipole'</p> <p>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'</p> <p>IGNORE 'intermolecular forces'</p>
2	(h)	(i)		2	<p>carbon backbone with Os and Hs correctly attached ✓</p> <p>rest correct ✓</p> <p>ALLOW ester reversed for one mark overall</p>
2	(h)	(ii)	<u>carbon-carbon</u> double bonds / C=C / alkene groups ✓	1	ALLOW 'double bond in hydrocarbon chain'
			Total	28	

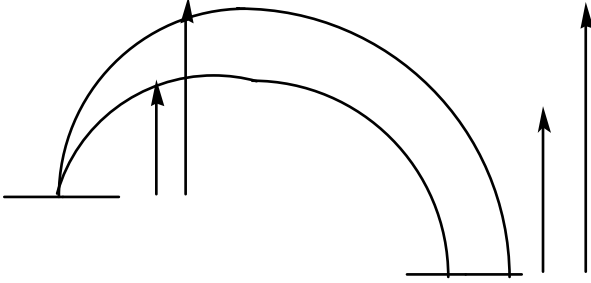
Question	Answer	Mark	Guidance
3 (a) (i)	 <p>structure ✓ 120±2 ✓ 104 – 120 ✓</p>	3	<p>angles of actual bonds in structure immaterial any bond angle around each atom can be indicated Bond angles must start and finish on bonds (allow ecf if bond angles 'fall short' twice)</p> <p>(large range for the nitrogen bond to allow for delocalisation)</p>
3 (a) (ii)	 <p>✓</p>	1	<p>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</p>
3 (a) (iii)	 <p>bonding on C and N correct ✓ arrangement of electrons on oxygen ✓</p>	2	<p>IGNORE any negative charges shown</p> <p>ALLOW other symbols for electrons</p> <p>ALLOW • x for • x</p>
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	<p>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)</p>

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)	$\Delta S_{\text{tot}} = (\text{answer to 3di}) + 92000/298 (= -198 + 309) \checkmark$ correct evaluation with correct sign given ✓	2	ALLOW more decimal places, provided rounding is correct +111 scores both marks; 111 scores one mark $\Delta S_{\text{tot}} = (\text{answer to 3di}) + 920/298$ 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 <i>followed</i> by correct signs
3	(e)	(ii)	$\text{NH}_3 + 3\text{H}_2\text{O} \rightarrow \text{HNO}_3 + 8\text{e}^- + 8\text{H}^+$ OR $\text{NH}_3 + 3\text{H}_2\text{O} \rightarrow \text{NO}_3^- + 8\text{e}^- + 9\text{H}^+ \checkmark\checkmark$	2	$\text{NH}_3 \rightarrow \text{HNO}_3 + 8\text{e}^-$ scores one mark whatever else is there there are no other ways of scoring one mark
3	(e)	(iii)	$\text{NH}_3 + \text{HNO}_3 \rightarrow \text{NH}_4\text{NO}_3 \checkmark$ 100% ✓	2	ALLOW $\text{NH}_4^+ \text{NO}_3^-$ no ecf second mark depends on first

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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 ₃ COOH (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 4 th 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)	 <p>product and reactant <u>lines</u> ✓</p> <p>catalysed and uncatalysed lines ✓</p> <p>indication that enthalpy change of activation is lowered for both forward and back reaction ✓</p> <p>One correct arrow (single or double ended) labelled E_a / 'activation enthalpy' ✓</p>	4	<p>Please annotate with ticks where the marks are scored</p> <p>ALLOW endo or exothermic or 'level'</p> <p>IGNORE labels for energy levels</p> <p>(need not be labelled)</p> <p>ALLOW catalysed line with intermediate</p> <p>indication can be by label or by note</p> <p>incorrect arrows CON correct arrows</p>
4 (d) (i)	<p>(lower $[\text{CO}_2]$) moves equm (position) to left ✓</p> <p>pH rises ✓</p>	2	<p>IGNORE 'less acidic' / 'more alkaline' / 'less H^+'</p> <p>Mark separately – NO ecf from 1st mpt</p>
4 (d) (ii)	<p>(equm) change happens (much) more slowly / does not happen without catalyst / pH does not change (much) / changes slowly ✓</p>	1	<p>IGNORE references to equilibrium position</p> <p>ALLOW 'not speeded up'</p>

Question		Answer	Mark	Guidance
4	(e)	$[\text{H}^+] = 4.0 \times 10^{-8} \checkmark (3.981071706 \times 10^{-8})$ $[\text{CO}_2] = 4.0 \times 10^{-8} \times 2.5 \times 10^{-2} / 4.5 \times 10^{-7}$ $= 2.2 \times 10^{-3} \checkmark \text{ ecf}$ (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 ' $\text{H}^+ =$ ' 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 \checkmark when acid/alkali added \checkmark in small quantities \checkmark <u>equilibrium</u> moves to left when acid added [ORA for alkali] \checkmark removing acid / H^+ [ORA for alkali] \checkmark large concentration of HCO_3^- \checkmark	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: $\checkmark \checkmark$ 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 ₃ CH(CH ₃)CH ₂ OH ✓ 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)		<p><i>3 main marks shown plus any three from bracketed marks:</i></p> <p>MS – M_r ✓ [different fragments, with one suggestion of a different fragment for one ester ✓]</p> <p>IR – bonds / functional groups ✓ [fingerprint, compared with known values ✓]</p> <p>[The esters both have same M_r (allow ecf from above) and bonds ✓]</p> <p>nmr – environments of protons/hydrogen atoms (ignore H⁺) ✓ [ratio of areas / intensities 6:1:2:1 or 3:2:2:3 ✓]</p> <p>[different shifts (with one correct detail of one ester) ✓]</p> <p>[splitting (with one correct detail of one ester) ✓]</p>	6	<p>Please annotate with ticks where the marks are scored</p> <p>ALLOW '(relative) molecular/formula mass' or 'molar mass', NOT just 'mass'</p> <p>fragments must have formulae but need not have charge</p> <p>'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</p> <p>B has 2.0 – 2.7; A has 9.4 – 10.0</p> <p><i>Last four bracketed marks all contain QWC link</i></p> <p>IGNORE inaccurate statements unless they actively CON a mark</p>

Question	Answer	Mark	Guidance
5 (d) (i)	<p>✓✓ 1 each</p>	2	<p>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.</p> <p>Extra arrows CON any correct arrows on the same molecule IGNORE arrows on right-hand two molecules</p> <p>Second arrow goes from double bond to oxygen. (line and arrow must extrapolate to touch the correct place)</p> <p>'half arrows' are not rewarded the first time they occur but can then be awarded by ecf (through into d(iii))</p>
5 (d) (ii)	water ✓	1	ALLOW H ₂ O
5 (d) (iii)	<p>arrow on Y ✓ arrow on Z ✓ R'OH ✓ H⁺ ✓</p>	4	<p>First arrow must go from bond to oxygen</p> <p>Second arrow must go from bond to bond (same extrapolation rules as above for both)</p> <p>ALLOW arrows from O-H bond to O and then from O to O-C bond</p> <p>Extra arrows CON any correct arrows on the same molecule</p> <p>IGNORE wrong attachments in R'OH</p> <p>ALLOW ROH for R'OH</p>
5 (e) (i)	CH ₃ COOH ⇌ CH ₃ COO ⁻ + H ⁺ ✓	1	<p>ALLOW CH₃COOH + H₂O ⇌ CH₃COO⁻ + H₃O⁺</p> <p>ALLOW C₂H₄O₂ ⇌ C₂H₃O₂⁻ + H⁺</p> <p>Must have equilibrium sign</p> <p>IGNORE state symbols</p>

Question			Answer	Mark	Guidance
5	(e)	(ii)	$([H^+] = [CH_3COO^-] =) 6.3 \times 10^{-4} \checkmark\checkmark$	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 \checkmark standard / known concentration \checkmark	2	IGNORE measuring out initial acid
5	(f)	(ii)	0.70 \checkmark	1	ALLOW 0.7
5	(f)	(iii)	Correct Kc expression, $[RCOOR] \times [H_2O] / [ROH] \times [RCOOH]$ (answer from (f)(ii) squared) / $0.4(0)^2$ (or correctly evaluated) \checkmark Correct evaluation of a given expression with (answer from (f)(ii) squared) on top and any two numbers on the bottom \checkmark (=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	