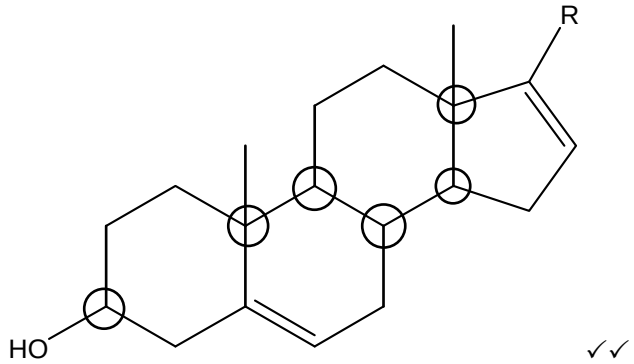
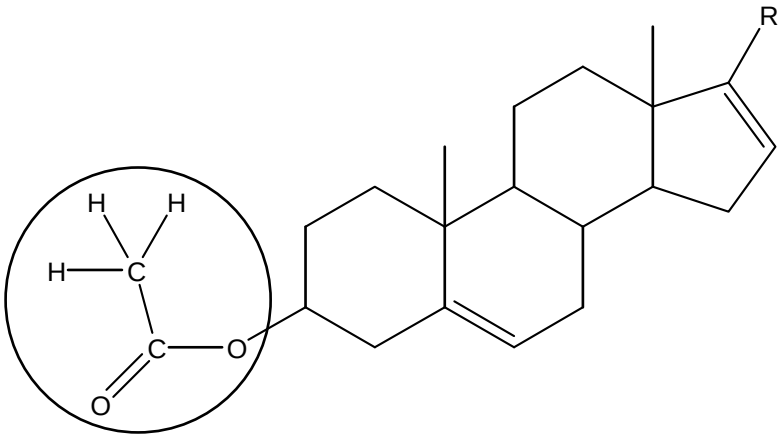
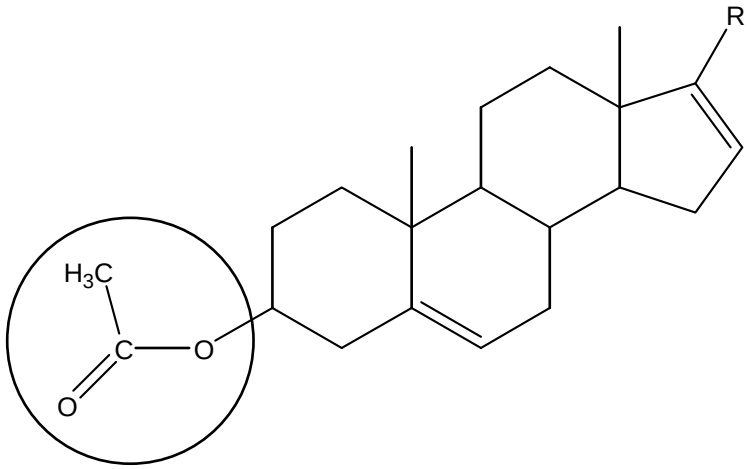
Question	Expected Answers	Marks	Additional Guidance
1 (a)	Alkene / carbon-carbon double bond / C=C ✓ alcohol / hydroxyl / hydroxy ✓	2	Double bond alone does **NOT** score. **ALLOW** secondary alcohol but not primary or tertiary. Do **NOT** allow hydroxide.
1 (b) (i)	 ✓✓	2	*If more than 3 circles,* any surplus INCORRECT ones are CON **IGNORE** surplus CORRECT circles 2 marks for 3 correct 1 mark for 2 correct 0 marks for only 1 correct
1 (b) (ii)	(The mirror images / molecules / structures / enantiomers / they) are non-superimposable / cannot be superimposed ✓	1	
1 (c) (i)	The **masses** of the different types of atom present are **not integers** / masses are measured relative to carbon-12 (12.00000) ✓ **OR** different compounds with the same whole number molecular mass will have **different M_r values** from high resolution spectra / AW ✓ **AND** Comparison of M_r with database / list of formulae/M_r values ✓	2	*mark independently* **ALLOW** high resolution MS gives accurate M_r to 4 decimal places **ALLOW** calculate molecular formula by using masses of atoms involved
1 (c) (ii)	Peak: CH_3^+ ✓ species lost = OH ✓	2	**MUST** have correct charge for first mark **MUST** be neutral for the second mark

Question	Expected Answers	Marks	Additional Guidance
1 (d) (i)	 ✓	1	**ALLOW** this, though not full structural! **DO NOT ALLOW** skeletal formula 
1 (d) (ii)	ethanoic acid ✓ <u>concentrated</u> sulfuric acid / <u>concentrated</u> hydrochloric acid ✓	2	*Mark separately* **IGNORE** conc./ dil. / aq. for ethanoic acid Moderately is CON for acid **ALLOW** correct formula. e.g. CH_3COOH and conc H_2SO_4
1 (e)	$C_{24}H_{31}NO$ + **$2Br_2$** → **$C_{24}H_{31}NOBr_4$** ✓	1	**ALLOW** correct formula to be given in any order of atoms

Question	Expected Answers	Marks	Additional Guidance
1 (f)	*Any **four** from:* 1. Heat the (impure) sample with solvent / use hot/warm solvent ✓ 2. with a minimum amount (of solvent) / add solvent to solid until just dissolves ✓ 3. filter ✓ 4. leave filtrate/solution/mixture to cool / leave to crystallise ✓ 5. filter off crystals, wash and dry ✓ **AND for QWC mark:** **EITHER** First filtration / filtration of hot solution removes **<u>insoluble</u>** impurities **OR** after crystallisation **<u>soluble</u>** impurities stay in solution / AW (QWC) ✓	5	**Please annotate with ticks to show where ALL marks are awarded** **IGNORE** *extra points after 4 have been scored* **IGNORE** name of solvent If no solvent is used then no marks can be scored similarly if **4.** is **incorrect** then **5.** cannot be scored **QWC** only one statement required for this mark **ALLOW** 'impurities which do **NOT** dissolve' / solid impurities **ALLOW** 'impurities which dissolve'

Question	Expected Answers	Marks	Additional Guidance
1 (g)	1. Is the drug safe (to be used in humans)? ✓ 2 Does it do the job it is designed to do? ✓ 3 Is it better than the standard treatment being used? ✓	3	*Alternative answers to the 3 answers on the left:* **IGNORE** incorrect answers, including 'is it toxic/harmful?', 'is it cost-effective?' 'can it be modified?' **NOTE** only one mark can be scored for each of the candidate's questions (e.g. 'effective and better' in one question only scores 1) 1. Are there any **side-effects**? / AW 1. What is the **safe-dose**? / AW 2. Is it **effective**? / does it work AW 3. Is it an **improvement** on other drugs? / AW 3. Can it be used to treat **other** symptoms/health problems / diseases? / AW **ALLOW** specific examples *e.g. can it be used to treat cancer?*
	Total	**21**	

Question	Expected Answers	Marks	Additional Guidance
2 (a)	$Fe + 2CH_3COOH \rightarrow Fe(CH_3COO)_2 + H_2$ ✓✓	2	**Correct formula** for H_2 **or** formula of salt✓ correct formulae **AND** balanced ✓ **ALLOW** $Fe(C_2H_3O_2)_2$ or $Fe^{2+}(CH_3COO^-)_2$ **DO NOT ALLOW** $Fe(II)(CH_3COO)_2$
2 (b) (i)	Fe atom: .... $3d^6\ 4s^2$ **OR** $4s^2\ 3d^6$ ✓ Fe(II) ion: .... $3d^6$ Fe(III) ion: .... $3d^5$ ✓	2	**Fe atom** correct ✓ **BOTH** ions correct✓ **IGNORE '**$4s^0$' for ions
2 (b) (ii)	Half-filled d-shell / Half-filled d-orbitals (more stable) ✓ **OR** $3d^5$ configuration / $3d^5$ arrangement is (more) stable (than $3d^6$) ✓	1	**ALLOW** 'paired electrons are less stable than if unpaired' ORA **ALLOW** in $3d^5$ electrons are in separate orbitals/d-subshells
2 (c) (i)	$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$ ✓✓	2	Formulae correct and balanced ✓ **ALLOW** $Fe^{2+}(OH^-)_2$ correct state symbols ✓ *if first mark not gained:* must be (aq) + (aq) → (s) *or* (aq) + (aq) → (s) + (aq)
2 (c) (ii)	Red-brown ppt is iron(III) hydroxide / (hydrated) iron(III) oxide ✓ Fe^{2+}/ Fe(II) ions/$Fe(OH)_2$ are oxidised / lose electrons ✓ (by) oxygen ✓ THIS IS DEPENDENT ON Fe(II) ion/compound being oxidised	3	**ALLOW** correct formula, $Fe(OH)_3$ / Fe_2O_3 / $Fe_2O_3.xH_2O$ **ALLOW** names May be shown by an equation: e.g. $Fe^{2+} \rightarrow Fe^{3+} + e^-$ $Fe(OH)_2 + O_2 \rightarrow Fe_2O_3$ **IGNORE** 'by air'

<table>
<tr><td>2 (d) (i)</td><td>$Ce(SO_4)_2$ ✓</td><td>1</td><td></td></tr>
<tr><td>2 (d) (ii)</td><td>1. moles of Ce^{4+} in titre = 0.100 x (18.5/1000) (= 0.00185) ✓

2. moles of Fe^{2+} in 25.0 cm^3 = 0.00185

moles of Fe^{2+} in 1000 cm^3 = 0.00185 x 1000 / 25.0 = 0.0740 ✓</td><td>2</td><td>The mark is for the working shown in bold

ALLOW answer to 2 sig figs i.e. 0.074 and ecf from 1</td></tr>
<tr><td>2 (e) (i)</td><td>1. moles of A in 100 cm^3 = 0.1(0) / 213 (= 4.695 x 10^{-4}) ✓

2. moles of A in 1000 cm^3 = 10 x 0.10 / 213
= 4.7 x 10^{-3} / 0.0047✓ 2sf</td><td>2</td><td>Remember that in calculations correct answer gets full marks with or without working
ALLOW 4.70 x 10^{-3} (3 sf)</td></tr>
<tr><td>2 (e) (ii)</td><td><table><tr><th>wavenumber / cm^{-1}</th><th>bond</th><th>location</th></tr><tr><td>3150</td><td>O-H</td><td>carboxylic acid</td></tr><tr><td>1715</td><td>C=O

✓</td><td>ketone AND/OR

carboxylic acid

✓</td></tr></table></td><td>2</td><td>BOTH bonds correct ✓

BOTH locations correct ✓</td></tr>
<tr><td>2 (e) (iii)</td><td>1. COOH / carboxylic (acid) / carboxyl group ✓

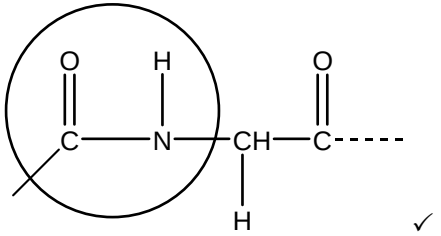
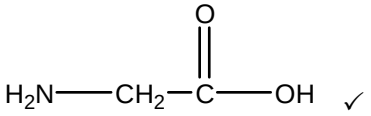
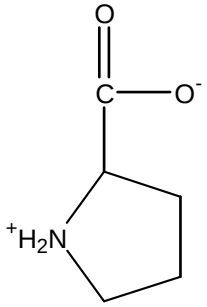
(reacts with alkali) to form:

2. ions in solution / a soluble salt / salt that dissolves / soluble carboxylate (allow formula) ✓

OR

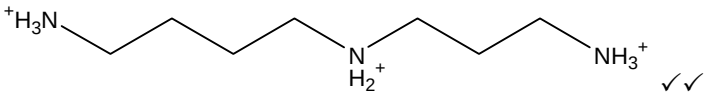
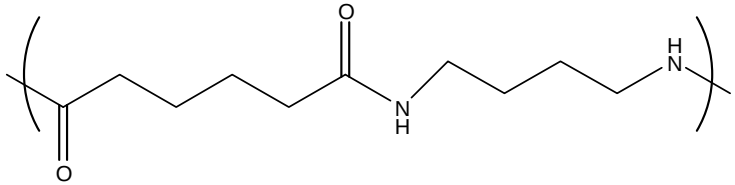
2. carboxylate/anion of carboxylic acid (allow formula) forms bonds with water</td><td>2</td><td>IGNORE references to intermolecular bonding</td></tr>
</table>

2 (f)	Any **5** from the following **6** marking points but **if no QWC maximum mark is 4** 1. Use an appropriate/suitable filter **OR** a filter having the complementary colour (if named must be yellow/green) ✓ 2. (Put a sample of the reaction mixture into the colorimeter and) take **absorbance** readings at set (time/regular) intervals AW ✓ 3. convert **absorbance** readings to concentrations using the calibration curve ✓ 4. plot graph of concentration v time **OR** 1/time for reaction ✓ 5. determine/measure /find half-lives from graph ✓ 6. constant half-life = first order ✓	5	**Please annotate with ticks to show marks awarded** If complementary ignore any other colour **QWC** 'absorbance' must be spelt correctly in either mark 2. or 3. for that mark to be allowed (this is NOT an extra mark) **ALLOW** 'absorbency' but NOT 'absorbancy' **NOTE** if no 'absorbance', max mark = 4 3. **ALLOW** for only one absorbance reading 4. **IGNORE** rate **ALLOW** points 5. and 6. may be shown using labelled diagrams 5. 'graph' must refer to concentration v time plot 5. find rate of reaction by drawing tangents on graph ✓ 6. if concentration doubles and rate doubles = first order / plot of rate v [B] gives (diagonal) line (through the origin) / directly proportional ✓
	Total	**24**	

Question	Expected Answers	Marks	Additional Guidance
3 (a) (i)	 ✓	1	**ALLOW** the linkage to proline ring (C,O and N atoms circled) **DO NOT ALLOW** if only the bond in C-N is circled
3 (a) (ii)	 ✓	1	**ALLOW** $H_2N–CH_2–COOH$ / full structure
3 (a) (iii)	 COO^- ✓ ring structure with NH_2^+ ✓	2	**Structure must be a zwitterion to score** **ALLOW** $COO^–$ **ALLOW** + charge on H or N
3 (b) (i)	(at high temperatures / 50°C) intramolecular/hydrogen bonds break ✓ and active site lost/altered/changed ✓	2	**IGNORE** intermolecular / any other types of intramolecular force / changing hydrogen bonds **ALLOW** bonds in tertiary structure **IGNORE** references to denaturing **ALLOW** 'active site is deformed/distorted' / no longer complementary/fits substrate **ALLOW** 'tertiary structure' for 'active site'

Question	Expected Answers	Marks	Additional Guidance
3 (b) (ii)	(change of pH) affects charges on polar/some/certain groups/ active site **OR** ionisable groups are altered ✓ prevents correct interactions/bonds between enzyme and substrate AW ✓	2	**ALLOW** a correct example (e.g. COOH, COO^-, NH_2, NH_3^+) **IGNORE** references to denaturing **ALLOW** ionic interactions/bonds are disrupted between enzyme and substrate **ALLOW** substrate does not fit/bind/react
3 (c) (i)	Rate = k x [**P**] x [enzyme]✓ mol^{-1} dm^{+3} s^{-1} ✓	2	**ALLOW** 'hydroxylase' *or* E *or* enz *or* complete name for enzyme **ALLOW** '(rate equation) = k x [**P**] x [enzyme]'; must have '=' **ALLOW** units in any order *and* dm^3 **ALLOW** '/' for '$^{-1}$' e.*g.* dm^{+3}/ mol/ s and sec^{-1} ecf for units
3 (c) (ii)	(When [**P**] is low) not all enzyme active sites are filled/saturated **OR** **P** can form a **P**-enzyme substrate (can be given as an equation) **OR** active sites available for substrates **OR** **P** can bind to active sites AW ✓ (as [**P**] increases) rate increases **in proportion** (so first order) AW ✓	2	**DO NOT ALLOW** 'there are an excess of enzymes' **ALLOW** the rate determining step is the formation of **P**-enzyme substrate / rds involves <u>one molecule</u> of **P** **DO NOT ALLOW** 'as [**P**] increases rate increases' alone. There must be some indication of how the rate increases e.g. rate doubles as [**P**]/conc. of **P**/amount of **P**/number of molecules of **P**/**P** doubles
3 (c) (iii)	all the <u>active sites</u> are filled/saturated (any increase in [**P**] will not affect the reaction rate) **OR** no <u>active site</u> is available for **P** to bind to/react with ✓ (so) **order** becomes/is **zero** ✓	2	**ALLOW** rds involves the breakdown of the enzyme-substrate complex (which does not depend on the concentration of P)

Question	Expected Answers	Marks	Additional Guidance
3 (d)	Any **two** from: **speeds up** reaction rate **reduces the number of steps** in a synthesis ✓ **improves the atom economy** AW ✓ **reduces the amount of energy/heat** required AW ✓ **easier separation** methods ✓ enzymes can be **reused/recycled** ✓ uses less toxic solvents/producing **less hazardous waste** no/fewer **organic solvents** used ✓ **reduces** use of more **toxic catalysts** ✓	2	**ALLOW** it is a one step process **ALLOW** lower temperature/pressure used/needed/required **IGNORE** renewed
	Total	**16**	

Question	Expected Answers	Marks	Additional Guidance
4 (a)	1,4-diaminobutane ✓✓	2	1,4-diamino ✓ **ALLOW** 1,4-diamine **DO NOT ALLOW** 1,4-butandiamine butane ✓ **ALLOW** butan (often in middle of name) but **DO NOT ALLOW** buta 1,6-diaminohexane scores 1 mark **IGNORE** gaps, commas and dashes
4 (b)	 ✓✓	2	extra H^+ on one amino group ✓ all correct ✓ **ALLOW** +ve charge on N or H **IGNORE** length of carbon chains / missing Hs on carbons **ALLOW** 1 mark if ALL 3 amino group Hs are correct but positive charge missing
4 (c) (i)	 ✓✓	2	amide group correct ✓ completely correct (including carbon chains) ✓ **ACCEPT** molecule the other way around. **ALLOW** structural formula or without brackets
4 (c) (ii)	(Secondary) amide ✓	1	**DO NOT ALLOW** peptide
4 (c) (iii)	Hydrogen chloride / HCl ✓ a small molecule/HCl has been eliminated/formed ✓	2	**DO NOT ALLOW** hydrochloric acid for the first mark **IGNORE** 'water formed'

4 (d)	Water (rather than HCl) is formed in the reaction ✓ HCl is toxic/harmful/dangerous/polluting (to the environment) / HCl needs to be disposed of **ORA** ✓ **ALTERNATIVE ANSWER** **C** contains chlorine ✓ which requires extra energy/resources to make AW ✓	2	*mark independently* **ALLOW** HCl causes acid rain / is corrosive *second mark depends on first*
4 (e) (i)	*Stanyl:* hydrogen bond(ing) ✓ *poly(ethene):* instantaneous (dipole)-induced dipole (bonds) ✓	2	**ALLOW** id-id bonding / van der Waals forces
4 (e) (ii)	intermolecular bonds in polythene are **weaker** than those in *Stanyl* ✓ **ORA** **less energy** / lower temperatures needed to break the imb in poly(ethene) / separate chains / enable chains to slide **ORA** ✓ **chains can move / slide over** each other (and polymer softens) ✓	3	**Please annotate with ticks to show where ALL marks are awarded** **ALLOW** intermolecular forces **ALLOW** for both marks named imb from 4 (e) (i), provided *Stanyl* bonds are stronger **ALLOW** less heat
	Total	**16**	

Question	Expected Answers	Marks	Additional Guidance
5 (a) (i)	Since $\underline{E}^{\ominus}$ for Cu(/Cu^{2+}) is more negative than Ag(/Ag^{+}) **ORA** ✓ electrons will flow/move (from Cu) to Ag / from Cu/(Cu^{2+} to Ag/Ag^{+} ✓	2	*mark independently* **ALLOW** smaller/larger since both $E^{\ominus}$ are positive **IGNORE** lower/higher **OR** references to redox processes **ALLOW** '$E^{\ominus}_{cell}$' for '$E^{\ominus}$', $E^{\ominus}$ for Cu(/Cu^{2+}) is less positive than Ag(/Ag^{+}) **ALLOW** 'from copper to silver' *or* 'Cu to Ag^{+}' **IGNORE** 'electrons flow through water' / attract / gain **DO NOT ALLOW** 'from Cu^{2+}'
5 (a) (ii)	0.46 V ✓	1	**ALLOW** + or – 0.46
5 (a) (iii)	$Cu + 2Ag^{+} \rightarrow Cu^{2+} + 2Ag$ ✓	1	**IGNORE** state symbols
5 (b) (i)	Oxidising agent = H^{+} /H_3O^{+} ✓ $E^{\ominus}$ values are measured with respect/compared to the (standard) H_2/H^{+} half-cell AW / $E^{\ominus}$ H_2/H^{+} = 0 ✓ metals with a negative electrode potential value will be oxidised by / will react with H^{+} ions/HCl AW **ORA** ✓	3	**ALLOW** hydrogen ions **ALLOW one mark** for saying acids/H^{+} can oxidise Zn but not Cu
5 (b) (ii)	1. Moles of Cu^{2+} in 250 cm^3 = **0.150 x (250/1000)** ✓ 2. Mass of copper in sample = 0.0375 **x** 63.5 = **2.381**✓ 3. % of Cu in brass = 2.381 / 3.97 x 100 = **60** ✓	3	1. The mark is for the working shown in bold **ALLOW** any number of sig. figs. **ALLOW** ecf from 1. and 2. **DO NOT ALLOW** 59
5 (b) (iii)	<table><tr><td></td><td>copper(II) complex formed with $EDTA^{4-}$</td></tr><tr><td>formula</td><td>$[Cu(EDTA)]^{2-}$</td></tr><tr><td>shape</td><td>octahedral</td></tr><tr><td>coordination number</td><td>6</td></tr></table> ✓ ✓ ✓	3	*Mark separately* 1 mark for each correct answer **ALLOW** without square brackets
	Total	**13**	