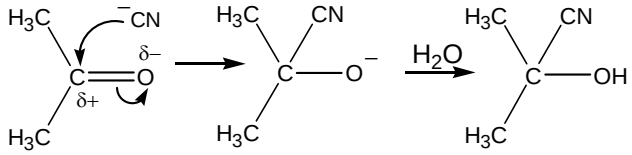
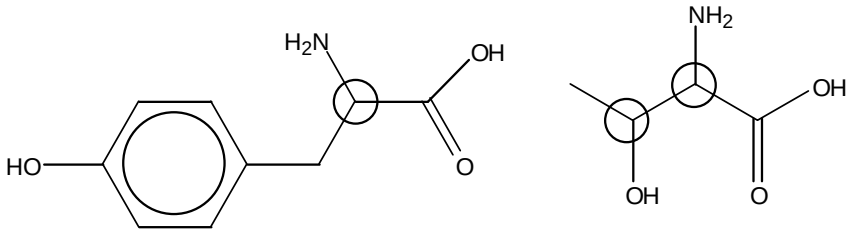
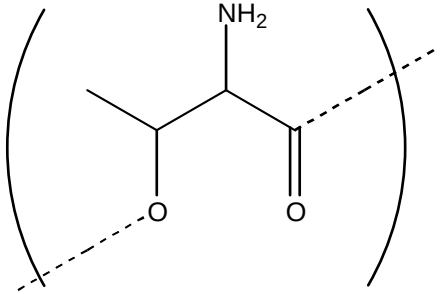
Question			Answer	Mark	Guidance
1	a	i	ethanal ✓	1	**DO NOT ALLOW** acetaldehyde
		ii	acidified / H^+ ✓ dichromate / $Cr_2O_7^{2-}$ ✓ distil ✓	3	**IGNORE** any sodium/potassium ions in formula/name **ALLOW** only sulfuric acid / H_2SO_4 **IGNORE** fractional **ALLOW** distillation **DO NOT ALLOW** if reflux is also stated
		iii	(strong) peak/trough at around 1720 (cm^{-1}) / *anywhere* in region **1700-1725 indicates C=O** (in carboxylic acid) (NOT PRESENT IN ETHANOL) ✓ (broad) peak/trough at around 3100 (cm^{-1}) / *anywhere* in region **2500-3200 indicates O-H** (in carboxylic acid) (NOT PRESENT IN COMPOUND A) ✓ ethanoic acid **OR** Compound B ✓	3	**OR** no peak above 3200 (cm^{-1}) OR in region of 3600-3640 (cm^{-1}) for –OH in alcohol **DO NOT ALLOW** No peak/trough at 1050-1300 for C-O in alcohol (cm^{-1}) *since peaks are present in this region* **ALLOW** no (strong) peak/trough at around 1720-1740 (cm^{-1}) for aldehyde group in compound A **DO NOT ALLOW** a carboxylic acid **ALLOW** labels on peaks in spectrum
		iv	Any suggestion that indicates that reflux/excessive heating took place / distillation of ethanal as it was formed did not take place **OR** **excess** acidified dichromate was used / acidified dichromate was not added slowly to ethanol ✓ (ethanol/ethanal was) <u>oxidised</u> further ✓	2	
1	b	i	ester ✓	1	

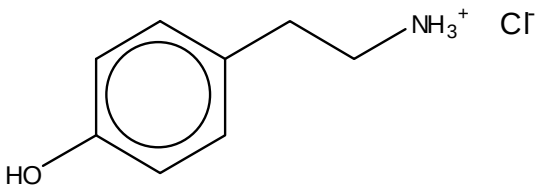
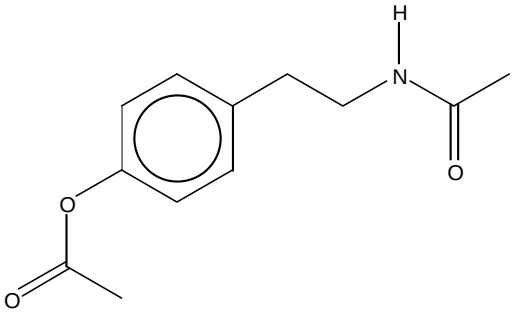
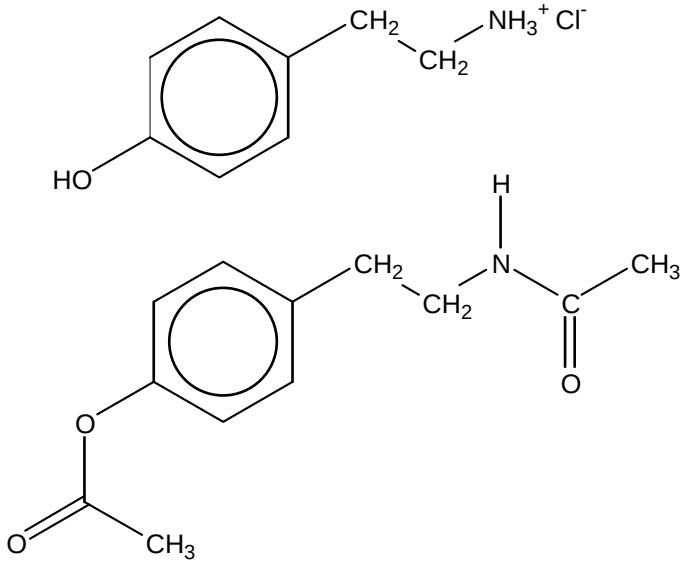
Question			Answer	Mark	Guidance
		ii	$C_2H_5OH + CH_3COOH \rightarrow CH_3COOC_2H_5 + H_2O$ ethanoic acid correct ✓ products correct ✓	2	**ALLOW** any correct type of structural formulae
		iii	concentrated sulfuric acid **OR** H_2SO_4 ✓ act as catalyst **OR** speed up reaction rate **OR** absorb water ✓	2	**IGNORE** references to activation enthalpy
		iv	reduces number of steps / increases atom economy **OR** could be cheaper **OR** could be faster **OR** reduces energy requirements **OR** can be carried out at low temperature **OR** can be reused ✓	1	

Question			Answer	Mark	Guidance
1	c		**ANY 5 POINTS FROM THE FOLLOWING 6:** 1. enzymes (are proteins / polypeptides) with a **specific** / *AW* **order** / sequence **of amino acids** ✓ 2. if the DNA is damaged the **primary structure** of the protein / **order of the amino acids** in the enzyme **will be altered** / changed ✓ 3. so the **tertiary structure**/folding of chains of the enzyme will also **alter** / change ✓ 4. the **active site** (is part of the tertiary structure and) is where the **reaction with the substrate** takes place *AW* ✓ 5. an altered active site will **not have the correct shape** ✓ 6. and (interact with the substrate) by **forming the correct** / *AW* **intermolecular bonds** / forces ✓ **AWARD QWC MARK FOR** altered/different active site linked to less/no reaction / enzyme does not work *AW* ✓	**6**	PLEASE ANNOTATE MARKS GIVEN WITH ✓ PUT ✓ for QWC next to 'pencil' icon **1. enzymes have a sequence of amino acids** **2. damage to DNA leads to different amino acids / primary structure** **3. resulting in different tertiary structure** **4. reaction takes place / substrate fits in at active site** **5. active site shape alters** **6. substrate can not bind/interact with active site OR can not form substrate-complex** **ALLOW** ….. by binding/bonding differently
				21	

Question			Answer	Mark	Guidance
2	**a**	**i**	T_g of PMMA is **above RT** so will be brittle / not enough energy to break intermolecular bonds / chains can not move over each other ✓ T_g of PMA is **below RT** so will be flexible/ rubbery / enough energy to break intermolecular bonds / chains can move over each other ✓	**2**	**IGNORE** any reference to crystallinity
		ii	chains in PMMA cannot move/slide over each other (easily) *ORA* ✓	**1**	*ORA* Chains in PMA can move over each other (easily) ✓
		iii	add a plasticiser / copolymerisation / add a copolymer ✓	**1**	**DO NOT ALLOW** cold-drawing
	b	**i**	intermolecular bonds in propene are instantaneous (dipole) – induced dipole ✓ intermolecular bonds in propanone are permanent (dipole) – permanent dipole ✓ more energy/higher temperature for propanone required ✓ because intermolecular bonds in propanone are stronger *ORA* ✓	**4**	**DO NOT ALLOW** id-id bonds **ALLOW** pd-pd bonds if an abbreviation is used for a second time **ALLOW** 1 mark if answer in terms of increased instantaneous – dipole induced dipole bonds (max mark is then 2)
		ii	hydrogen cyanide / cyanide ion ✓	**1**	**ALLOW** HCN / CN^- **ALLOW** potassium cyanide / sodium cyanide **OR** KCN / NaCN **IGNORE** acid or alkali

Question			Answer	Mark	Guidance
2	b	iii	 curly arrows correct on propanone ✓ partial charges correct on C=O ✓ correct anion formed ✓ correct reaction with H_2O or H^+ or HCN ✓	4	**ALLOW** mechanism if HCN is shown attacking but arrow must come from H-CN bond Curly arrow from nucleophile **MUST** come from carbon in either CN ion or HCN **ALLOW** CN^- for ion if arrow correct
		iv	(cyanide ion is a nucleophile and) the lone pair/electrons (which attack the electron deficient carbon) are on C (not N) ✓ **OR** nucleophile is **:**CN^- ✓	1	**ALLOW** the negative charge is on C **IGNORE** any reference to triple bond in CN
		v	few atoms wasted/high atom economy ✓	1	**ALLOW** 100% / no waste
	c	i	(moderately) concentrated acid ✓ (heat under) reflux ✓	2	**ALLOW** aqueous / dilute acid / H^+ and water **DO NOT ALLOW** conc. sulphuric acid or any form of alkali
		ii	amide ✓	1	**IGNORE** any qualification of amide i.e primary etc. **IGNORE** any given formulae **DO NOT ALLOW** peptide
		iii	only **F** ✓ there are (2) different groups on each C (of the double bond) ✓	2	marks are independent **DO NOT ALLOW** …on each side of C=C
				20	

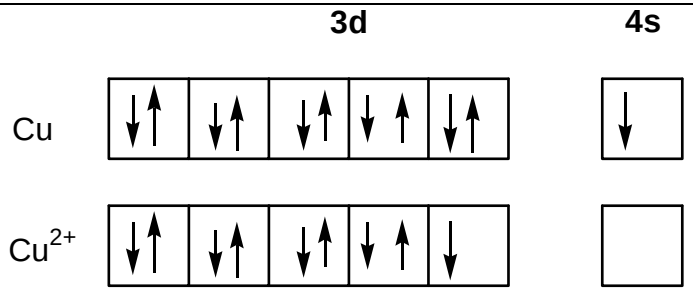
Question			Answer	Mark	Guidance
3	a		Tyrosine: <u>phenol</u> ✓ Threonine: <u>alcohol</u> ✓ add (neutral) $FeCl_3$ / iron(III) chloride ✓ Tyrosine: turns purple/violet **AND** Threonine remains yellow /does not change colour ✓	4	**ALLOW** orange **BUT NOT** brown alone for colour of $FeCl_3$ **ALLOW** acidified dichromate ✓ – Threonine goes green **AND** Tyrosine remains orange / does not change colour ✓
	b		 Tyrosine: correct: 1 chiral centre ✓ Threonine correct: 2 chiral centres ✓	2	
	c		 1 mark for correct repeating unit ✓ ester ✓	2	**IGNORE** brackets and *n* full structural / skeletal formula not required **ALLOW** multiple repeating units showing correct ester linkage

Question			Answer	Mark	Guidance
3	d	i	**with HCl**  1 mark for -NH_3^+ group correct ✓ 1 mark for rest of ion correct ✓ **with CH_3COCl**  and HCl 1 mark for each acyl group ✓✓ 1 mark for HCl (**IGNORE** number of HCls) ✓	5	**ALLOW** correct (full) structures but H's must be shown **ALLOW** –NH_3+ve ion without Cl^- 
		ii	phenols / phenol group / -OH group on tyramine will form ion / react with alkalis ✓ ionic substances / salts are (more) soluble in water **OR** ions interact / bond / with water (molecules) **OR** ions are attracted to water (molecules) ✓	2	**ALLOW** …… forms salts
				15	

Question			Answer	Mark	Guidance
4	**a**		water / H_2O ✓	**1**	
	b	**i**	**1**. (fill) **burette** with $KMnO_4$ / MnO_4^- solution ✓ **2**. use bulb / volumetric / graduated / 25 cm^3 / 10 cm^3 **pipette** for sodium ethanedioate ✓ **3**. to place solution in flask / beaker and then **acidify** (and warm flask) ✓ **4**. then add $KMnO_4$ / MnO_4^- solution **slowly** (*AW*) near end point ✓ **5**. until **permanent <u>pink</u>** colour *AW* ✓	**5**	PLEASE ANNOTATE MARKS GIVEN WITH ✓ **QWC:** Either **burette** or **pipette** must be spelled correctly to get both marks for **1** and **2**; **2.** pipette must be qualified by type as shown **OR** by saying 'pipette a known / *stated (e.g. 25 cm^3)* volume' for **1-4 ALLOW** different ways of describing each solution, either by an appropriate name or formula **3.** If acid is named **ONLY ALLOW** sulfuric acid **4. ALLOW** alternatives – *e.g. swirling and use of white tile* **5. ALLOW** pink colour persists / remains /is constant **ALLOW** 'pale pink/purple' **BUT NOT** 'purple' alone **DO NOT ALLOW** if indicator is used **IF SOLUTIONS REVERSED** 1 AND 2 score 1 mark only 5. becomes… permanent *AW* <u>colourless</u> solution So max mark = 4 **IGNORE** any reference to rough titrations
4	**b**	**ii**	moles of sodium ethanedioate = **0.0500 x 250/1000** (= 0.0125) ✓ mass = **((moles of ethanedioate) x 134)** correctly evaluated (1.675(0) g) ✓	**2**	**the marks are awarded for the working out given in bold** **ALLOW** 2 - 5 sig. figs. **ecf** for moles in mass calculation

Question			Answer	Mark	Guidance
		iii	**1**. moles of $C_2O_4^{2-}$ = **0.0500 x 10/1000** (= 0.000500) ✓ **2**. moles of MnO_4^- = **2/5** x 0.0500 x 10.0/1000 (= 0.000200) ✓ **3**. concentration = 2/5 x 0.0500 x 10/1000 x **1000/26.0** ✓ **4**. = **0.00769** / 7.69 x 10^{-3} 3 significant figures ✓	**4**	**the marks are awarded for the working out given in bold** IF FINAL ANSWER IS INCORRECT PLEASE ANNOTATE MARKS GIVEN WITH ✓ **1**. moles of $C_2O_4^{2-}$ = correct concentration x correct volume in dm^3 **2**. moles of MnO_4^- = 2/5 x moles of $C_2O_4^{2-}$ **3**. concentration = moles of MnO_4^- x 1000/26.0 **4**. must be to 3 significant figures **ecf** from **2** and **3**
4	**c**	**i**	**1**. transition metal ion / Cu^{2+} reacts with one of reactants (to form a product) **OR** reacts to form an intermediate (compound) ✓ **2**. oxidation state of the transition metal ion / Cu^{2+} changes **OR** metal ion can be oxidised or reduced **OR** metal ion can lose or gain electrons ✓ **3**. new ion / intermediate then reacts to reform the original transition metal ion / Cu^{2+} *AW* **OR** form original oxidation state at end of reaction *AW* ✓ **4**. activation enthalpy / energy for this reaction is lower than without the transition metal ion / Cu^{2+} ✓	**4**	PLEASE ANNOTATE MARKS GIVEN WITH ✓ **IGNORE** any name / formulae given to the intermediate **ALLOW** transition metal ions have variable oxidation states
		ii	Homogeneous ✓	**1**	

Question			Answer	Mark	Guidance
	d	**i**	during the reaction only the $[MnO_4^-]$ would be effectively changing *AW* **OR** the $[C_2O_4^{2-}]$ and $[H^+]$ would be (effectively) constant *AW* ✓	**1**	
		ii	calculate at least 2 half-lives (construction lines for two half lives shown on graph) ✓ value of at least 2 half-lives quoted as 14.5±1 (s) ✓ half-life is constant ✓	**3**	
		iii	$6.7 \times 10^{-4} = k \times 1.20 \times 10^{-3}$ ✓ k = 0.56 (0.558) ✓ units = s^{-1} ✓	**3**	**ALLOW** 2+ sig figs **IGNORE** $time^{-1}$
				24	

Question			Answer	Mark	Guidance
5	a	i	 1 mark each ✓✓	2	**ALLOW single** arrow in either direction
		ii	Cu forms an <u>ion</u> with an incompletely/partly filled set of <u>d</u> orbitals / (sub) shells / energy levels ✓	1	
	b	i	the $E^{\ominus}$ of oxygen/OH^- is more positive/less negative than that for Cu^{2+}/Cu ORA ✓ <u>O_2/oxygen</u> will oxidise Cu / gain electrons from Cu (forming Cu^{2+})✓	2	ORA The $E^{\ominus}$ of Cu^{2+}/Cu is less positive/more negative than oxygen/OH^- **DO NOT ALLOW** more/less electronegative/electropositive **DO NOT ALLOW** higher/lower ORA
		ii	the $E^{\ominus}$ of Fe^{2+}/Fe is more negative/less positive than that for Cu^{2+}/Cu so Fe reacts/corrodes instead of Cu *AW* ✓	1	
	c		$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$ equation correct ✓ state symbols correct ✓	2	EQUATION MUST BE BALANCED

Question			Answer	Mark	Guidance
5	d		**EITHER** barrier protection: Paint / grease / plastic coating / galvanising ✓ prevents copper reacting/corroding with oxygen/air **AND** water ✓ **OR** sacrificial protection: coat with/strap on blocks of Mg or Zn / galvanise ✓ the more reactive Mg or Zn corrodes/reacts instead of Cu ✓		
				10	