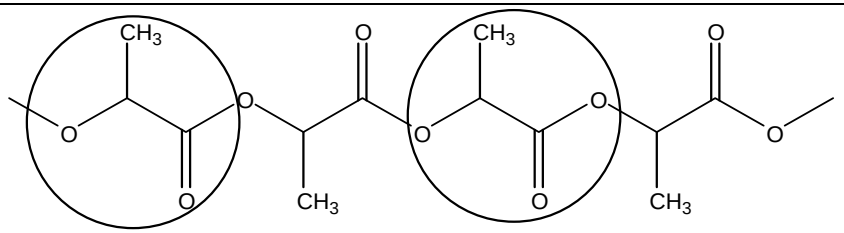
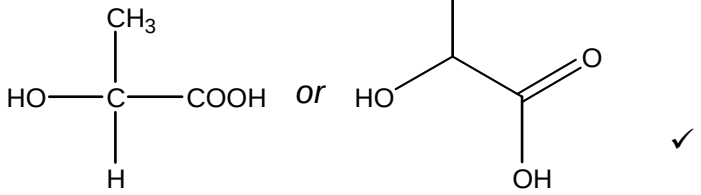
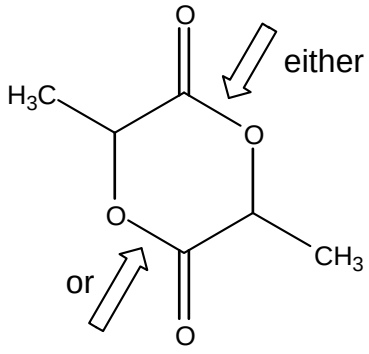
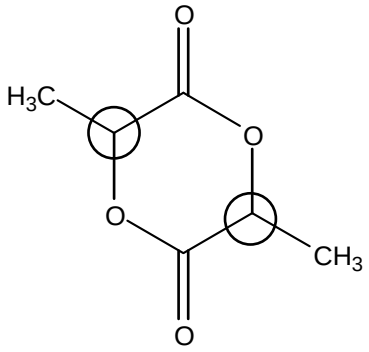
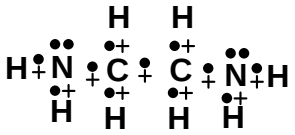
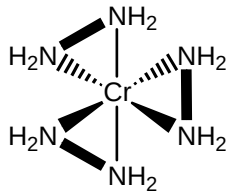
Question			Answer	Marks	Guidance
1	(a)	(i)	 ALLOW AT ANY POSITION ✓ **DO NOT ALLOW**	1	**DO NOT ALLOW** if -COO one side and no -O on the other
		(ii)	ester ✓	1	**ALLOW** polyester
	(b)		 ✓	1	**ALLOW** skeletal or partial skeletal formula as long as structure is correct
	(c)	(i)	 ✓	1	**ALLOW** if both arrows are shown

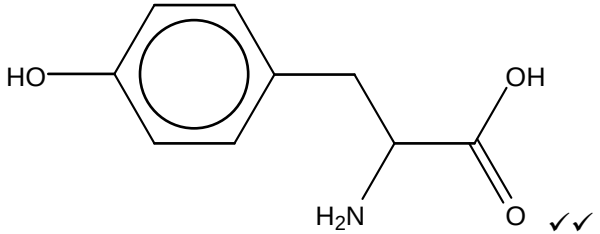
Question			Answer	Marks	Guidance
		(ii)	**no water** is produced in the reaction ✓ no polymer broken down/lost **OR** no polymer bonds broken ✓	**2**	**DO NOT ALLOW** 'no reaction with water' alone must refer to polymer being broken down etc.
		(iii)	polymerisation of **B** has a higher atom economy / 100% atom economy **OR** polymerisation of **A** has a lower atom economy ✓ (for polymerisation of **B**) all atoms are used / no waste is formed **OR** (for polymerisation of **A**) waste is formed ✓	**2**	**ALLOW** less waste is formed **for** no waste is formed **DO NOT ALLOW** no molecule lost from **B**
	(d)	**(i)**	not superimposable on its mirror image ✓	**1**	**ALLOW** has an asymmetric carbon atom **OR** carbon atom attached to four different groups **DO NOT ALLOW** carbon atom attached to four different **functional** groups / atoms / molecules **DO NOT ALLOW** 'chiral atom' for 'carbon atom'
		(ii)	 ✓	**1**	

Question			Answer	Marks	Guidance
	(e)	**(i)**	how polymer chains/molecules/sections are packed together in an orderly/regular way **OR** how polymer chains/molecules/sections are aligned/lined up ✓	**1**	**ALLOW** chains are highly ordered some sort of particles have to be ordered' etc. 'ordered structure' is not sufficient **DO NOT ALLOW** 'chains are packed closely' alone
	(e)	**(ii)**	above T_m: polymer **melts**/becomes **liquid**/fluid ✓ below T_g: polymer becomes **brittle** ✓ because chains cannot **move over each other** ✓ so **break** when a **force is applied** ✓ (blended polymer is more crystalline) so **intermolecular bonds**/**forces** / imbs / imfs are **stronger** **AND more energy** is needed to separate chains/melt polymer (QWC) ✓	**5**	**please annotate marks given with ticks** **ALLOW** glass transition temperature and melting temperature for T_g and T_m **IGNORE** references to rigid, flexible, amorphous, crystalline **ALLOW** more crystalline means more points of contact for imbs/imfs **OR** more iimbs/imfs **INSTEAD** of stronger imbs/imfs
	(f)		manufactured from a renewable source / starch / plants **OR** not manufactured from oil/natural gas ✓	**1**	
			Total	**17**	

Question			Answer	Marks	Guidance
2	(a)	(i)	carbon dioxide / CO_2 ✓	1	
		(ii)	oxidation states: Fe(+2) to Fe(+3) ✓ Cr(+3) to Cr(+6) ✓ an increase in oxidation state / loss of electrons ✓	3	**DO NOT ALLOW** + sign after / absent ; for first oxidation state ecf for rest **ALLOW** correct Roman numerals for 1 mark only
		(iii)	sodium/disodium chromate(VI) ✓	1	oxidation state must be correct **AND** after 'chromate' **ALLOW** without brackets around oxidation state **ALLOW** gaps **IGNORE** (I) after sodium
	(b)		$2Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$ H_2O ✓ rest correct and balanced ✓	2	**IGNORE** state symbols *or* Fe_2O_3 as reactant AND product in equation
	(c)		filtration / centrifuge ✓	1	**IGNORE** vacuum
	(d)		(Cr(III) cannot be reduced by carbon but Fe(III) can so) **Fe_2O_3 has greater** oxidising strength than Cr_2O_3 **OR** **Cr_2O_3 has lower** oxidising strength than Fe_2O_3 ✓	1	
	(e)	(i)	**Cr^{3+}(aq)/Cr(s) half-cell**: Cr^{3+}(aq) in beaker and Cr electrode labelled ✓ voltmeter **AND** salt bridge correctly connected ✓ standard conditions: concentration is 1 mol dm^{-3} **AND** temperature is 298K / 25ºC ✓	3	**ALLOW** Cr(III) or soluble salt *e.g.* sulfate or nitrate **ALLOW** electrode if totally immersed if not labelled as salt bridge **ALLOW** correct formula/name for chemical in salt bridge *i.e any soluble sodium, potassium or ammonium salt* **IGNORE** pressure **ALLOW** 1M / 1 mol $litre^{-1}$

Question			Answer	Marks	Guidance
		(ii)	$2Cr(s) + 6H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3H_2(g)$ reactants and products correct ✓ state symbols correct **AND** balanced ✓	**2**	**ALLOW** 1 mark if equation is the other way round but balanced with correct state symbols **ALLOW** 1st mark only if electrons are included but reactants and products are correct **ALLOW** if balanced using $1.5H_2$
		(iii)	*electronegativity*: ...ability of <u>atom</u> to <u>attract</u> <u>electrons</u> ✓ in a (covalent) <u>bond</u> ✓ *conclusion*: **Fe^{2+}** is a **stronger** oxidising agent than **Cr^{3+}** ✓ because the ***$E^{\ominus}$* of Fe^{2+}/Fe** half-cell is **more positive/less negative** than that of the **Cr^{3+}/Cr** half-cell ✓	**4**	**ALLOW** …<u>atom</u> to pull <u>electrons</u> … **ORA** this means: **Cr** is a **stronger** reducing agent than **Fe** ✓ because the ***$E^{\ominus}$* of Cr^{3+}/Cr** half-cell is **less positive/more negative** than that of the **Fe^{2+}/Fe** half-cell ✓ **ALLOW *$E^{\ominus}$* of Fe/iron** half-cell / ***$E^{\ominus}$* of Cr/chromium** half-cell **BUT NOT FOR** oxidising agents formulae reasoning in last marking point is only for correct conclusion **ECF** use of ions for reducing agents
	(f)		transfer/exchange of proton **OR** a proton is lost/donated **AND** gained/accepted ✓ $[Cr(H_2O)_6]^{3+}$ **AND** H_3O^+ ✓	**2**	**ALLOW** H^+ for proton **DO NOT ALLOW** 'Cr complex ion' without formula
	(g)	**(i)**	1,2-diaminoethane ✓	**1**	**IGNORE** commas and dashes **ALLOW** ethylenediamine **BUT NOT** ethan(e)-1,2-diamine

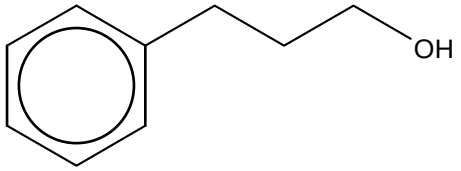
Question			Answer	Marks	Guidance
		(ii)	 **ALL** bond pairs correct ✓ **BOTH** lone pairs correct ✓	**2**	**ALLOW** two crosses for lone pair
		(iii)	it can use/donate **two**/**both** lone pairs (of electrons) ✓ to form dative covalent/coordinate bonds (with metal cation) ✓	**2**	**ACCEPT** 'free' pair of electrons
	(h)	(i)	6 ✓	**1**	
		(ii)	 where ▬ represents $-CH_2CH_2-$ 3D octahedral diagram showing 6 bonds from central atom ✓ 3 bidentate ligands linking pairs of adjacent bonds ✓	**2**	**IGNORE** charge on Cr or complex ion **DO NOT ALLOW** 2D diagrams **ALLOW** any representation for the carbon chains
		(iii)	90 (º/degrees) ✓	**1**	
		(iv)	it has an asymmetric structure / it is chiral **OR** its **mirror image** / the **two isomers** is/are non-superimposable ✓	**1**	
			Total	**30**	

Question			Answer	Marks	Guidance
3	(a)		condensation ✓	1	
	(b)	(i)	(moderately) concentrated hydrochloric acid/HCl ✓ boiling/heating (under reflux) ✓	2	**ALLOW** mod. conc. sulfuric acid **BUT NOT** conc. H_2SO_4 **ALLOW** reflux **DO NOT ALLOW** other named acids / mod. conc. acid alone
		(ii)	 ✓✓	2	1st mark for having a $–NH_2$ and a –COOH group 2nd mark for rest of structure correct **ALLOW** –COOH, structural formula for carbon chain
	(c)	(i)	colorimetry ✓	1	
		(ii)	forms a **purple** colour ✓ with *Tyr* because of the **phenol** group ✓	2	
	(d)	(i)	the <u>three dimensional shape/structure</u> of the protein **OR** folding of the secondary structure / α-helix / β-pleated sheet **OR** overall folding of the protein/polypeptide ✓	1	**DO NOT ALLOW** 'overall shape of the protein'
		(ii)	changing pH affects the ionic/electrostatic attractions / charges on groups ✓ so by lowering pH $–COO^-$/carboxylate can be protonated/can form –COOH **OR** lowering pH NH_2 protonated to NH_3^+ ✓	2	**ALLOW** hydrogen bonding **DO NOT ALLOW** 'intermolecular bonds/forces' alone

Question			Answer	Marks	Guidance
	(e)	(i)	to help judge the disappearance of the suspension / milkiness AW **OR** makes milky suspension easier to see AW **OR** makes the change from milky/white to clear/colourless easier to see ✓	1	**IGNORE** any reference to colour change other than white-colourless
		(ii)	to act as a control / to compare with the suspension (and so judge/determine the end of the reaction) ✓	1	**DO NOT ALLOW** 'to compare test-tubes' alone
		(iii)	read off **rate** / 1/t on y-axis for (a particular) **temperature** on x-axis ✓	1	**ALLOW** correct construction shown on diagram
		(iv)	**1st mark:** as the temperature rises particles have more energy ✓ **2nd mark:** more collisions have energy greater than the activation enthalpy/energy ✓ **3rd mark:** graph falls because at high temperatures intermolecular bonds break ✓ **4th mark:** loss of active site **OR** shape of active site changes **OR** tertiary structure of enzyme changes / is altered / unable to form enzyme-substrate complex ✓ **QWC** to gain the **2nd mark** the spelling of activation enthalpy/energy has to be correct	4	**IGNORE** references to enzyme–substrate complexes for marks 1-3 **ALLOW** system/molecules/enzymes and substrates have more energy **ALLOW** hydrogen bonds / bonds holding the tertiary structure together **BUT NOT** 'intramolecular bonds' or 'bonds' alone **IGNORE** the use of 'denature' etc.

Question			Answer	Marks	Guidance
	(f)		$3.08 \times 10^{-3} = k \times 0.010 =$ **0.308** ✓ $k = 3.1 \times 10^{-1} / 0.31$ ✓ units: s^{-1} ✓	**3**	**ALLOW** any correct rearrangement of equation **2 sf** only ecf for units for using incorrect rate equation
	(g)		Zero order ✓ all the active sites are full **OR** maximum number of enzyme-complexes have formed **OR** all enzymes have combined with substrate molecules ✓	**2**	
			Total	**23**	

Question			Answer	Marks	Guidance
4	(a)		how to dissolve/administer/form a suspension of the oil **OR** find out dilution which is a non-irritant AW **OR** dose which is safe AW ✓	1	**DO NOT ALLOW** to find if it is more effective, cost **ALLOW** dose which does not irritate the skin
	(b)		draw **pencil-line** near bottom of plate and place 1 **drop** (or similar word) **of mixture** (and a drop of each of the 3 compounds) on the line ✓ place plate in solvent, **line above solvent** level **AND** add **lid/cover** ✓ when solvent nears **top of plate**, **remove/dry** plate ✓ locate spots with **UV light/iodine** ✓ **compare** heights/position of spots from mixture with the 3 standard compounds **OR** **calculate R_f** values of spots and compare with those of the standards (may be named) ✓	5	**please annotate marks given with ticks** **ALL** marking points may be gained from labelled diagram(s) **DO NOT ALLOW** paper for plate **BUT** ecf for further use **DO NOT ALLOW** 'locating agent' alone
	(c)		alkene / C = C ether phenol/hydroxy(l) **ALL** correct 2 marks ✓✓ **ANY 2** correct 1 mark ✓	2	**DO NOT ALLOW** double bond, formulae **DO NOT ALLOW** alcohol

Question			Answer	Marks	Guidance
	(d)		Eugenol/phenol reacts with NaOH to form salt/soluble product ✓ alcohols do not react with NaOH **OR** no phenol group in linalool so no reaction ✓	**2**	**ALLOW** for 1st mark formula of ions forming salt eg -0^{-} Na^{+} **DO NOT ALLOW** 'linalool does not react' without reference to a phenol or alcohol functional group
	(e)		(peak at) 3200–3640 (cm^{-1}) indicates –OH (in alcohol) ✓ no (strong) peak at (about) 1720–1740 (cm^{-1}) so no C=O group (in aldehyde) ✓  ✓	**3**	may be shown on the diagram of the spectrum **ALLOW** any value or range of values for peak within the range may show $-CH_2-$ groups
	(f)		acidified dichromate ✓ heat / reflux ✓	**2**	**ALLOW** any concentration of acid **ALLOW** formulae, sulfuric acid for acid, potassium or sodium salt

Question			Answer	Marks	Guidance
	(g)		1. concentration of standard Na_2CO_3 solution = **0.6625/106.0** ✓ = 0.00625 mol dm^{-3} 2. moles of carbonate (CO_3^{2-}) used = **10.80/1000** x answer from **1** ✓ = 0.0000675 3. moles (of $H^+(aq)$) in 50 cm^3 cinnamic acid = **2** x answer from **2** ✓ = 0.000135 4**.** moles (of $H^+(aq)$) in 1000 cm^3 cinnamic acid = **1000/50** x answer from **3** ✓ = 0.0027 5. solubility of cinnamic acid = 148.2 x (answer from **4**) = **0.400** ✓	**5**	0.4 with no / incomplete working scores 5 marks. **The marks are awarded for the working out given in bold** **ALLOW** ecf between each step **If final answer is incorrect please annotate marks given with ticks** **ALLOW** any sig figs
			Total	**20**	