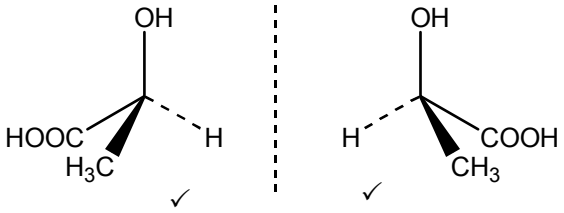
F334 Chemistry of Materials

Question	Expected Answers	Marks	Additional Guidance
1 (a)	2-hydroxypropanoic acid ✓✓	2	mark independently 2-hydroxy ✓ **DO NOT ALLOW** hydroxy**l** propanoic acid ✓ **ALLOW** if propan- and -oic are separated.
(b) (i)	(enantiomers are) isomers whose structures are <u>mirror images</u> of one another ✓ and are <u>non-superimposable</u> ✓	2	mark independently mirror images ✓ non-superimposable ✓ **IGNORE** references to 4 different groups around a C atom, optical isomerism, various chiral words & rotation of plane polarised light
(ii)	 ✓ ✓	2	3D structure correct for one isomer ✓ **DO NOT ALLOW** 90 or 180 degree angles between the two bonds in the plane of the paper mirror-image correct (must have 4 bonds around the C)✓ **ALLOW** ecf for non 3D structure with four different groups only **IGNORE** the way the groups are bonded to carbon eg -OH or –HO, same for COOH & CH_3
(c) (i)	P = **C** Q = **A** ✓ R = **B**	1	

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(ii)	P = (**C**) does not fizz / does not react / with Na_2CO_3 **AND** so no –COOH group present / AW ✓ Q = no phenol group (in **A**), so $FeCl_3$ remains yellow / AW ✓ R = (**B** has) **both** phenol & carboxylic acid (COOH) (so will turn $FeCl_3$ purple and will fizz with Na_2CO_3) / AW ✓ ***The words in brackets are only needed if tests not discussed for P & Q.***	**3**	if answers to **(i)** are incorrect/no response award 1 mark for correct answers for having **both tests** for phenol and carboxylic acid: *ie:* purple solution = phenol **AND** acids fizz with carbonate ✓ **IGNORE** P is **C** as it turns $FeCl_3$ purple **IGNORE** Q is **A** as it fizzes & is therefore a carboxylic acid
(d)	**C** ✓ because: (broad) peak at around 3250 (cm^{-1}) indicates alcohol or phenol / OH / hydroxyl group ✓ no peak at 1700–1725 (cm^{-1}) so no C=O (in –COOH) present ✓	**3**	 **IGNORE** any reference to carboxylic acid for the 3250 peak **ALLOW** a range around 3250 Peaks may be identified on the diagram **IGNORE** all other peaks
(e) (i)	nucleophilic addition ✓✓	**2**	nucleophilic ✓ addition ✓ mark independently

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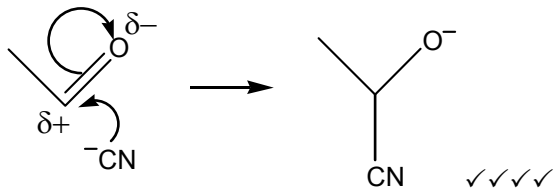
(ii)	 ✓✓✓✓	4	'curly' arrow showing attack by $^{-}$CN at C=O **carbon** ✓ **DO NOT ALLOW** arrow starting from N of $^{-}$CN / single-headed arrows but give 1 mark if both are single headed but otherwise correct C=O bond polarised correctly ✓ curly arrow showing movement of double bond ✓ final structure correct **ALLOW** any correct structural formula not just skeletal ✓ O **MUST** be –ve **IGNORE** any further reaction showing O^{-} gaining H^{+}
(iii)	the rate determining step (slow step) does not involve water ✓ (since) water does not appear in the rate equation / water is zero order✓ Since water / H+ required to form product it must react in a subsequent (fast) step/there must be at least 2 steps in the reaction / AW ✓ **OR** the rate determining step (slow step) <u>only</u> involves ethanal & cyanide ✓ (because only) ethanal & cyanide appear in the rate equation ✓ and so <u>water</u> must react in a subsequent step ✓	3	

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(f) (i)	reaction 1.1 has a higher atom economy than reaction 1.2 ✓ because it is an **addition** reaction / only one product is formed **whereas** in reaction 1.2 **hydrolysis** / condensation occurs / atoms are wasted / lost / two 'products' are formed / co-products are also formed / AW ✓	**2**	**ALLOW** comparison of percentage atom economy *eg* reaction 1.1 has 100% economy, reaction 1.2 does not. **IGNORE** any reference to substitution / elimination for reaction 1.2 / by-product
(ii)	reduce / cut down on / less / little **waste** (products) ✓ **costs** of are kept to a minimum / less energy used ✓	**2**	 **ALLOW** cost effective
	Total	**26**	

Question	Expected Answers	Marks	Additional Guidance
2 (a)	Fe^{3+} will oxidise Cu / ORA **OR** Cu loses electrons to form Cu^{2+} / ORA ✓ because **electrode potential of Fe^{3+} / (Fe^{2+}) is more positive** / ORA (involves the Copper half-cell) **OR** Uses E_{cell} calculation to show reaction is feasible✓ $Cu + 2Fe^{3+} \rightarrow Cu^{2+} + 2Fe^{2+}$ ✓	3	**ALLOW** Fe(**III**) and Cu(**II**) **DO NOT ALLOW** electronegativity or higher / lower or larger / smaller **IGNORE** state symbols
(b) (i)	**Pt electrode** for Fe^{3+} / Fe^{2+} half cell ✓ in **Fe^{3+} / Fe^{2+}** ✓ Cu electrode in Cu^{2+} ✓ salt bridge labelled and in solutions ✓ conditions: 1 mol dm^{-3} and 298K / 25ºC ✓	5	 **ALLOW** $CuSO_4$ etc. instead of Cu^{2+} **ALLOW** 1 molar / 1M
(ii)	0.43 V ✓	1	**IGNORE** any sign
(c) (i)	Copper(**I**) iodide ✓	1	**DO NOT ALLOW** copper iodide **ALLOW** Copper **I** iodide

Question	Expected Answers	Marks	Additional Guidance
(ii)	1. moles of thiosulfate = 0.200 x (20.5/1000) = **0.0041** ✓ 2. (moles of iodine (I_2) = 0.5 x answer from **1** (0.0041) **and** moles of $Cu^{2+}(aq)$ in 25.0 cm^3 = 2 x **0.5** x answer from **1** (0.0041)) = 0.0041 ✓ 3. moles of $Cu^{2+}(aq)$ in 250 cm^{-3} = 10 x answer from **1** (0.0041) = 0.0410 ✓ 4. mass of Cu in coin = answer from **3** (0.0410) x **63.5** = 2.6035 g ✓ 5. % of Cu in coin = (answer from **4** (2.6035)/3.47) x 100 = **75.0** ✓ 6. (3 sig. figs.) ✓	**6**	75.0 with no / incomplete working scores 6 marks. **The marks are awarded for the working out given in bold**: If final answer is incorrect please annotate marks given with ticks AND crosses where errors have occurred *eg* missing out step 3. 1. moles of thiosulfate = 0.0041 moles 2. correct moles of $Cu^{2+}(aq)$ in 25.0 cm^3 ecf from 1 ✓ 3. moles of $Cu^{2+}(aq)$ in 250 cm^{-3} = **10** x moles of thiosulfate ✓ 4. mass of Cu in coin = moles of $Cu^{2+}(aq)$ in 250 cm^{-3} x **63.5** ✓ 5. % of Cu in coin = mass of Cu in coin x 100 ✓ 6. correct/incorrect answer **MUST** be given to 3 sig figs. ✓ **Steps 3 & 4** may be in a different order
(d) (i)	(transmits) Blue ✓ $Cu^{2+}(aq)$ **absorb** red / orange light ✓ **QWC** – absorb(s) / absorbing / absorption / absorbance / absorbed One of these words has to be used to gain the second mark and spelling must be correct	**2**	**IGNORE** pale, deep or light etc. referring to blue, reflects **DO NOT ALLOW** green **ALLOW** complementary colour / specific frequencies / wavelengths of light are absorbed **DO NOT ALLOW** all other frequencies / colour / AW Use of 'emit' is a **CON** for the 2nd mark

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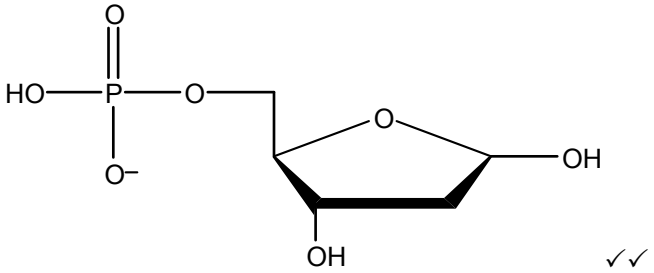
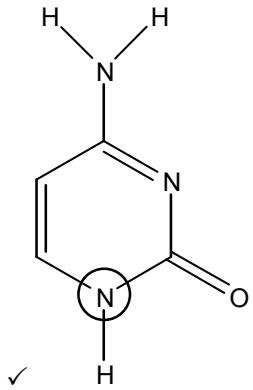
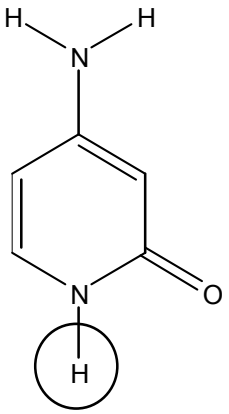
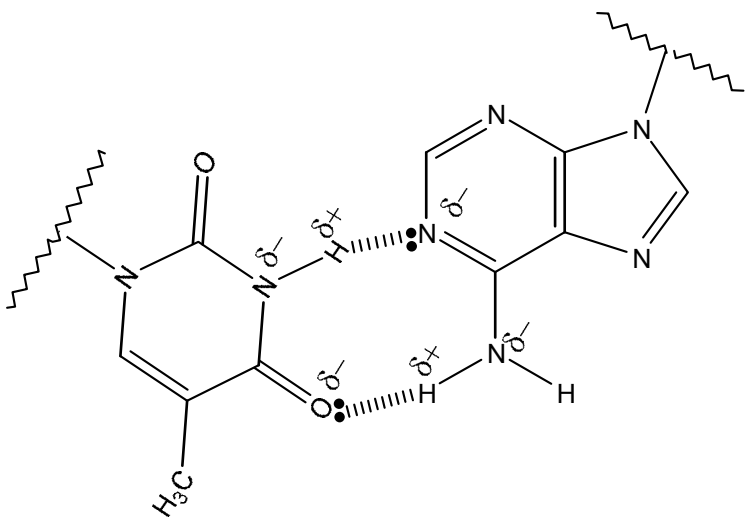
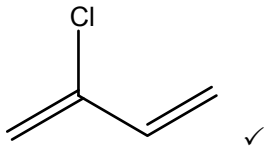
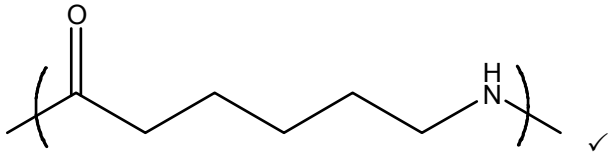
(ii)	Ligand substitution ✓ $[CuCl_4]^{2-}$ ✓	2	**ALLOW** ligand replacement / displacement / exchange or complex formation The charge is required **ALLOW** $[Cu(H_2O)_2Cl_4]^{2-}$
(iii)	*Any **five** from a-f:* ✓✓✓✓✓ a. make up standard solutions / of known concentrations (of $Cu^{2+}(aq)$) b. choose a suitable filter / set the colorimeter to a suitable wavelength c. zero colorimeter with water / solvent / AW d. measure **absorbance / absorption** of standard solutions / AW e. plot calibration curve f. measure unknown **AND** g. **QWC** read off concentration from calibration curve / AW ✓	6	 **IGNORE** transmittance
	Total	26	

Question	Expected Answers	Marks	Additional Guidance
3 (a) (i)	 ✓✓	2	the link between phosphate group and any –OH group on the sugar *ie* **P-O-CH_2-C** (in ring next to –O-) or **P-O-C** (in ring) depending which -OH group is used ✓ correct linkage (**P-O-CH_2-C**) and rest of structure correct ✓
(ii)	Water / H_2O **and** condensation (reaction) ✓	1	
(iii)	 ✓	1	**ALLOW**  **ALLOW** if the **N-H** group is circled
(iv)	lone pair (of electrons) on N / amine (group) ✓ accepts a proton / H^+ ✓	2	

Question	Expected Answers	Marks	Additional Guidance
(b)		**3**	2 hydrogen bonds correct ✓ **DO NOT ALLOW** more than 2 bonds correct polarities (all 3) on **one** group of atoms ✓ lone pair on the N **OR** O ✓
(c)	two strands (not three) ✓ phosphate groups on the outside (not on the inside) ✓ bases face into the centre (not the outside) ✓	**3**	**ALLOW** double helix **IGNORE** phosphate backbone
(d)	**for** removal: infringement of personal liberty / AW / 'fingerprint' not unique only probability / techniques used not foolproof / law / type of government might change changing accessibility / AW ✓ ***against*** *removal:* helps to solve many crimes, particularly 'cold' crimes / 'innocent until proved guilty' / AW ✓ future research into disease	**2**	**IGNORE** hacking into database / leakage of data (NOTE: probability may only be 1 in 20 for some population groups)
	Total	**14**	

Question	Expected Answers	Marks	Additional Guidance
4 (a)	 ✓  ✓	2	1 mark for each structure correct **DO NOT ALLOW** missing H atoms if structural formulae are drawn
(b) (i)	there are (two) different groups on each carbon of a C=C in neoprene ✓ these groups can not rotate about the double bond ✓	2	May be shown in a diagram **ALLOW** restricted / limited rotation about the double bond
(ii)	(**less trans** linkages) will make the **chains less linear** / less regular / less ordered / ORA ✓ so they can not line up / be arranged so regularly / closely **and** the crystallinity will be reduced ✓	2	**ALLOW** chains have a kink / are more randomly arranged Note: 1st mark is for **shape** of chain, 2nd mark is for **relative arrangement** of chains.
(c)	–CONH group / NH group / amide group allows nylon to form hydrogen bonds with water molecules ✓ no hydrogen bonding in neoprene ✓ water molecules will force chains further apart / chains will not fit as closely together / AW ✓ chains less crystalline / weaker intermolecular forces so T_g will be lowered ✓	4	**IGNORE** chains sliding over each other

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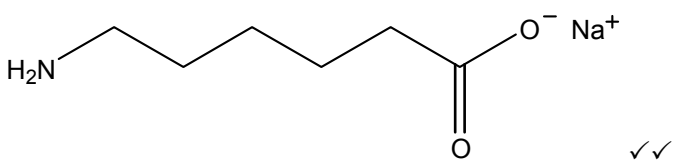
(d)	 ✓✓	2	6 carbon atoms and $–NH_2$ group ✓ $–COO^-$ ✓ **ALLOW** skeletal or any equivalent / alternative structural formula **DO NOT ALLOW** structures with missing H atoms
	Total	**12**	

Question	Expected Answers	Marks	Additional Guidance
5 (a) (i)	$\mathbf{3}H_2S + \mathbf{2}MnO_4^- + 2H^+ \rightarrow \mathbf{2}MnO_2 + \mathbf{3}S + 4H_2O$ ✓	1	all **4** numbers **MUST** be correct
(ii)	oxidation state = +4 ✓	1	**DO NOT ALLOW** 4+ **OR** 4
(b) (i)	iron(**III**) hydroxide ✓	1	**DO NOT ALLOW** iron hydroxide / $Fe(OH)_3$
(ii)	$Fe^{3+}(aq) + \mathbf{3}OH^-(aq) \rightarrow Fe(OH)_3(s)$	2	equation correct ✓ state symbols correct ✓ **ALLOW** ecf for iron(**II**) hydroxide in **(i)**
(c) (i)	The large excess of ethanedioate and acid means that their concentrations were virtually constant during the reaction / concentrations hardly changed / concentrations were high so little effect on rate / AW ✓	1	*'A large excess of ethanedioate and acid'* by itself does not get the mark **IGNORE** 'excess ethanedioate and acid not limit the rate of reaction' / AW *Look for* **concentration** *in answer*
(ii)	**One** of the following: Method 1 half-lives determination of at least two half-lives, 13-15 s ✓ half-life constant ✓ first order ✓ **OR** *Method 2 finding rate at different concentrations* calculation of at least two rates ✓ rate is proportional to concentration ✓ first order ✓	3	Two values for half-life **MUST** be given Working must be shown as either a calculation or by lines on graph.

Question	Expected Answers	Marks	Additional Guidance
(iii)	**3d** **4s**  ✓	1	
(d)	**One** from the following: loss of CO_2 / CO_2 produced ✓ by weighing / gas collection / measuring milkiness of lime-water ✓ **OR** titration of MnO_4^- ✓ with (standard) $Fe^{2+}(aq)$ ✓ **OR** titration of $H^+(aq)$ decrease ✓ with OH^- / $CO_3^{2-}(aq)$ ✓ **OR** measure pH change ✓ H^+ ions used in the reaction ✓	2	The two parts are marked independently **ALLOW** gas for CO_2 and measuring volume for gas collection
	Total	12	