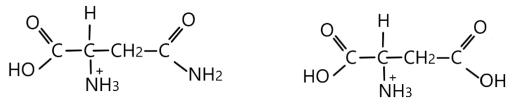
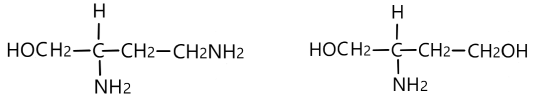
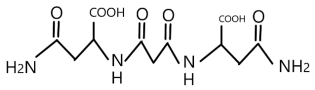
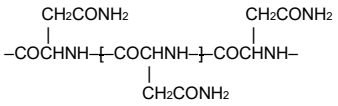
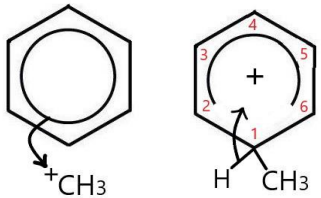
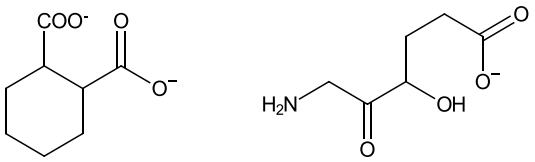
8(a)	the pH at which an amino acid exists as a zwitterion
8(b)	**M1:** $[HOOCCH(NH_3)CH_2CONH_2]^+$ **M2:** $[HOOCCH(NH_3)CH_2COOH]^+$ 
8(c)	**M1:** $HOCH_2CH(NH_2)CH_2CH_2NH_2$ **M2:** $HOCH_2CH(NH_2)CH_2CH_2OH$ 
8(d)(i)	$HOOCCH_2COOH + 2SOCl_2 \rightarrow ClOCCH_2COCl + 2SO_2 + 2HCl$ [1]
8(d)(ii)	$HOOCCH(CH_2CONH_2)NHCOCH_2CONHCH(CH_2CONH_2)COOH$ **M1:** three molecules joined, with four correct amide groups only **M2:** whole structure correct as above, displayed formula accepted, skeletal formula as below accepted 
8(e)	**M1:** hydrolysis of amide to carboxylate ion **M2:** hydrolysis of –COOH to carboxylate ion and rest of molecule $^-OOCCH(NH_2)CH_2COO^-$

8(f)	• three monomer residues • all linkages correct • correct trailing bonds • repeat unit marked contains correct atoms Any two [1], any three [2], all four [3] 
8(g)(i)	• rotate the plane of the plane polarised light • by the same angle • in opposite directions Any two [1], all three [2]
8(g)(ii)	racemic mixture

9(a)	• all C atoms are sp^2 hybridised • bonds between C atoms are σ and π • C–C σ bonds are formed by overlap of sp^2 hybrid orbitals • C–C π bonds are formed by overlap of p orbitals • bonds between C and H atoms are σ • C–H bonds are formed by overlap of sp^2 hybrid orbitals and s orbitals Any two [1], any four [2], all six [3]
9(b)	CH_3Cl and $AlCl_3$
9(c)	 **M1:** curly arrow from within hexagon towards ^+C **M2:** intermediate, usual rules for horseshoe and + charge **M3:** curly arrow from C–H bond into ring **AND** H^+ product
9(d)	**M1:** HNO_3 **AND** H_2SO_4 **M2:** concentrated **AND** 25 °C ⩽ T ⩽ 60 °C
9(e)	alkaline $KMnO_4$
9(f)	4-nitrobenzoic acid
9(g)	(hot) concentrated HCl and Sn
9(h)	**M1:** perform step 3 before step 2 **OR** perform step 2 before step 1 **M2:** COOH is 3-directing **OR** NO_2 is 3-directing

8(a)	• chlorobenzene is less reactive than ethanoyl chloride • p orbital / lone pair on Cl / –Cl will overlap / delocalise into the ring **OR** C of COCl has most electron deficient **OR** has an electronegative oxygen atom / two electronegative atoms / electron withdrawing C=O group • due to partial double C–Cl bond **OR** C–Cl bond strengthened (more) / stronger bond between Cl and benzene / ring **OR** C–Cl weakened in ROCl any two [1], all three [2]
8(b)(i)	• nitrile • amide • ketone / carbonyl • ester any two [1], all four [2]
8(b)(ii)	8 / eight
8(b)(iii)	no need to separate optical isomers

8(c)	 **M1:** amide bond hydrolysed and COO^- and NH_2 formed **M2:** nitrile bond hydrolysed and COO^- formed **M3:** ester bond hydrolysed and COO^- and OH formed
8(d)(i)	percentage = $100 \times 28 / (28 + 58 + 13 + 42) = 19.9\,(\%)$ min 2sf
8(d)(ii)	**D** is attracted more strongly to the stationary phase **/** forms stronger intermolecular forces with the stationary phase