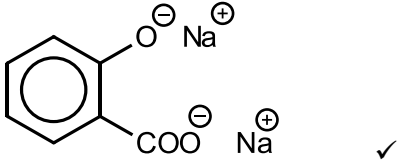
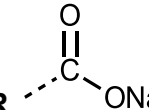
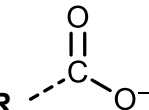
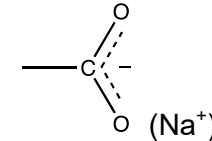
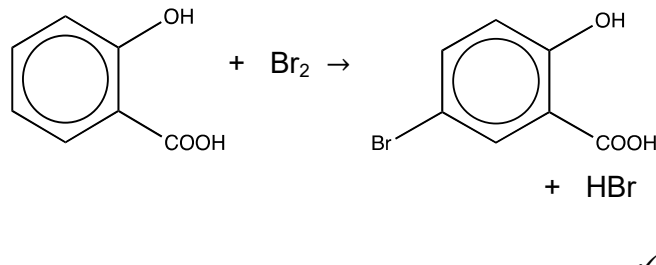
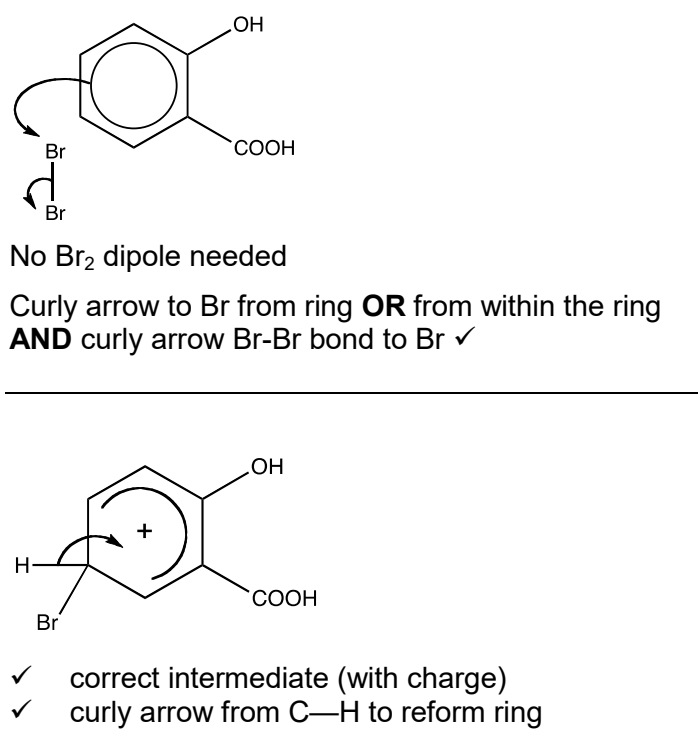
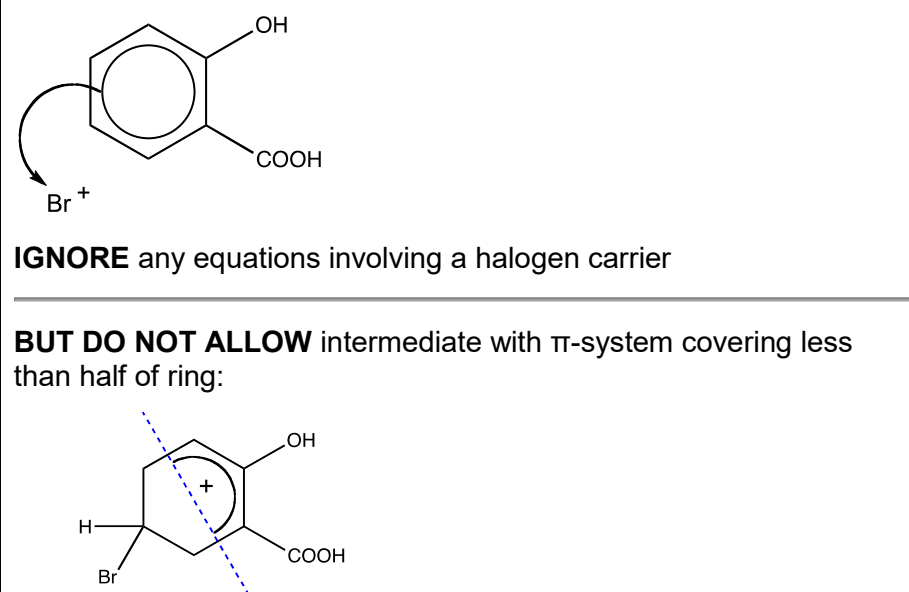
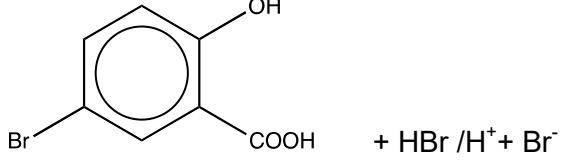
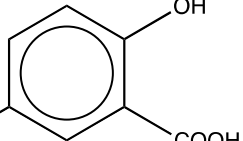
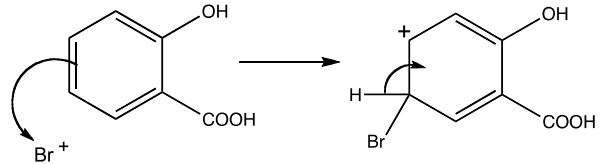
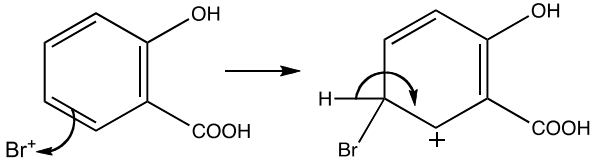

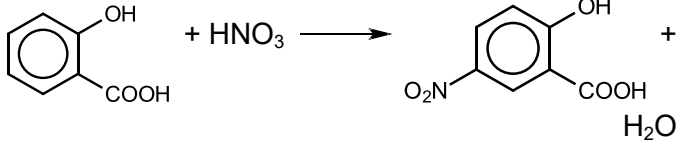
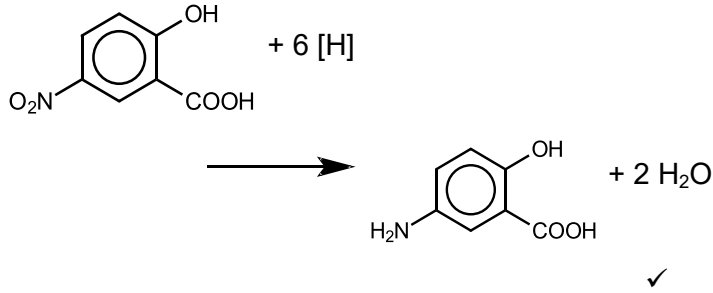
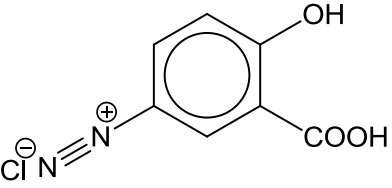
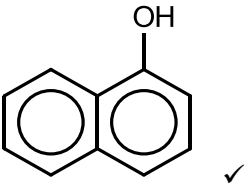


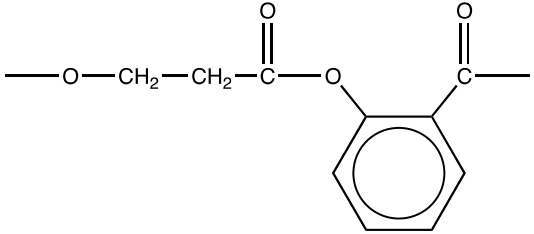
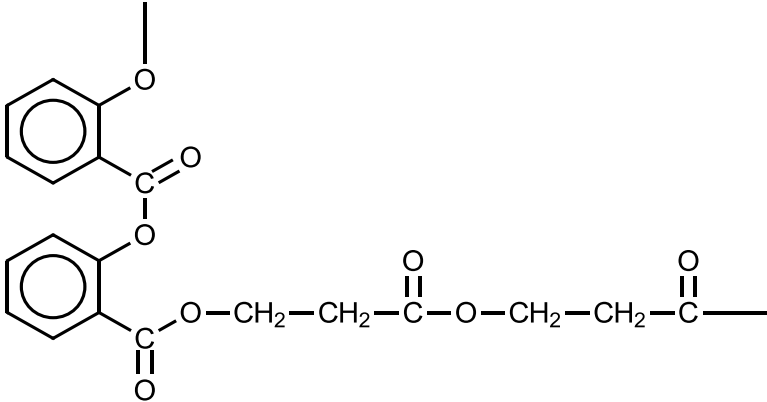
Question			Answer	Mark	Guidance
Where circles have been placed round charges, this is for clarity only and does not indicate a requirement					
1	(a)	(i)		1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>DO NOT ALLOW —O—Na OR -COO-Na (covalent bond)</p> <p>ALLOW —O⁻</p> <p>ALLOW —ONa ALLOW —COONa OR  OR </p> <p>ALLOW delocalised carboxylate</p> 
1	(a)	(ii)	<p>(Bromine) would be decolourised/turn (from orange/red/yellow/brown) to colourless</p> <p>OR white precipitate/solid/emulsion (formed) ✓</p>	1	<p>IGNORE goes clear</p> <p>DO NOT ALLOW other colours for bromine</p> <p>IGNORE cream precipitate</p> <p>DO NOT ALLOW salicylic acid turns colourless/decolourised</p> <p>IGNORE temperature/fumes</p>
1	(a)	(iii)		1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>MUST be all correct to score mark</p> <p>ALLOW molecular formulae, i.e. $C_7H_6O_3 + Br_2 \rightarrow C_7H_5O_3Br + HBr$</p>

Question			Answer	Mark	Guidance
1	(a)	(iv)	$(\text{CH}_3)_2\text{CHOH}/\text{CH}_3\text{CH}(\text{OH})\text{CH}_3/\text{propan(-)2(-)ol}$ AND acid/ H^+ / H_2SO_4 (catalyst) ✓	1	ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous ALLOW 2-propanol DO NOT ACCEPT incorrect name or incorrect formula of alcohol IGNORE reflux/concentrated (acid)
1	(b)	(i)	 <p>No Br_2 dipole needed</p> <p>Curly arrow to Br from ring OR from within the ring AND curly arrow Br-Br bond to Br ✓</p> <hr/> <p>✓ correct intermediate (with charge) ✓ curly arrow from C—H to reform ring</p>	4	ALLOW mechanism with Br^+ electrophile (Maximum 3 marks)  <p>IGNORE any equations involving a halogen carrier</p> <hr/> <p>BUT DO NOT ALLOW intermediate with π-system covering less than half of ring:</p> <p>ALLOW + charge anywhere inside the 'horseshoe' Horseshoe must have open end towards Br</p> <p>Apply ecf to error in structure of intermediate (M2)</p>

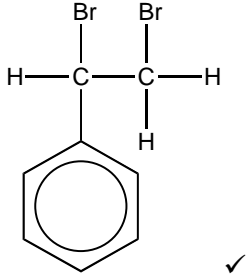
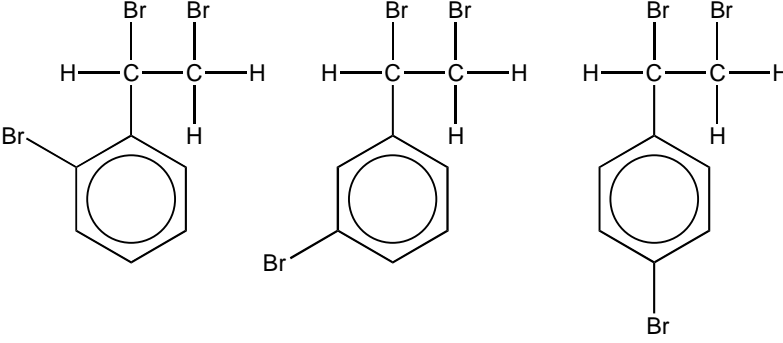
Question	Answer	Mark	Guidance
	 <p> Br^-  $+\text{HBr} / \text{H}^+ + \text{Br}^-$ </p> <p> ✓ Correct products (Br^- may be shown in the first step) </p>		<p>ALLOW Kekulé mechanism as shown (Maximum 3 marks if Br^+ is the electrophile)</p>  <p>ALLOW double bonds in alternate arrangement</p> 

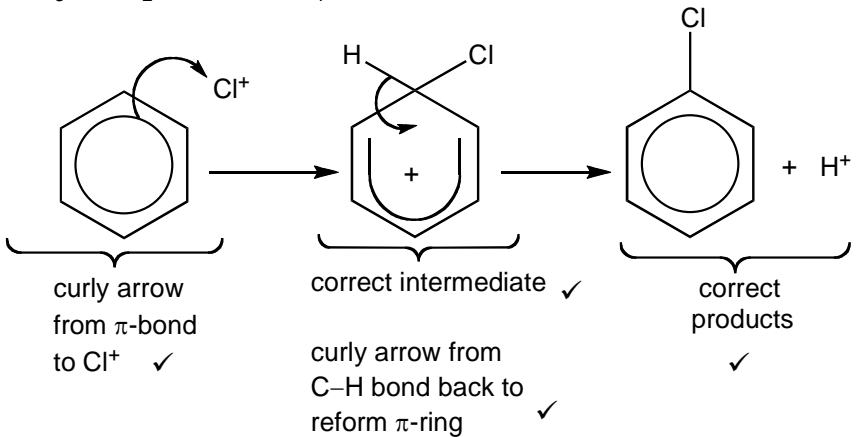
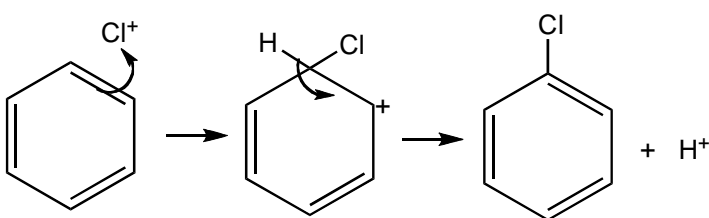
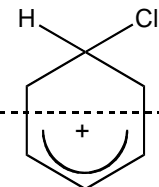
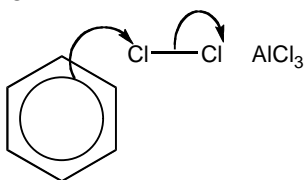
Question			Answer	Mark	Guidance
1	(b)	(ii)	<p>(In salicylic acid) lone pair/pair of electrons on O(H)/phenol is ~ (partially) delocalised into the ring ✓</p> <p>electron density increases/is high ORA ✓</p> <p>Br₂/electrophile is (more) polarised ORA ✓</p> <p> QWC: delocalised/delocalized/delocalise etc. must be spelled correctly in the correct context at least once</p>	3	<p>ALLOW diagram to show movement of lone pair into ring but delocalised ring must be mentioned</p> <p>ALLOW lone pair/pair of electrons on O(H)/phenol is (partially) drawn/attracted/pulled into delocalised ring</p> <p>IGNORE 'activates the ring'</p> <p>ALLOW more electron rich</p> <p>DO NOT ALLOW charge density or electronegativity</p> <p>ALLOW (salicylic acid) attracts electrophiles more/more susceptible to electrophilic attack</p> <p>ALLOW Br₂ is (more) attracted OR Br₂ is not polarised by benzene OR induces dipoles (in bromine/electrophile)</p> <p>Delocalise(d) needed to score the first marking point</p>
1	(c)	(i)	<p>Step 1 Add HNO₃ ✓</p> <p>  </p>	4	<p>ALLOW reagent mark if HNO₃ in equation</p> <p>IGNORE H₂SO₄ (NOTE: H₂SO₄ not required with phenols)</p> <p>IGNORE concentrations of acids/temperature</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>Equations MUST be completely correct for one mark each</p>

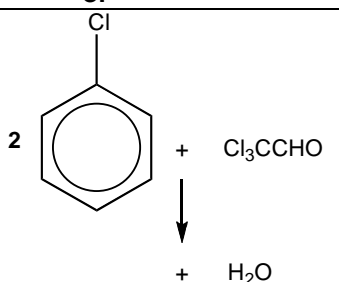
Question			Answer	Mark	Guidance
			<p>Step 2</p> <p>Tin AND concentrated HCl ✓</p> 		DO NOT ALLOW 3H ₂
1	(c)	(ii)	Nitrogen electron pair OR nitrogen lone pair accepts a proton/H ⁺ ✓	1	<p>DO NOT ALLOW nitrogen/N lone pair accepts hydrogen (proton/H⁺ required)</p> <p>ALLOW nitrogen donates an electron pair/lone pair to H⁺</p> <p>IGNORE NH₂ group donates electron pair</p>
1	(c)	(iii)	<p>compound A ✓</p>  <p>compound B ✓</p> 	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>ALLOW —N₂Cl OR —N₂⁺Cl⁻</p> <p>DO NOT ALLOW —N≡N⁺ OR —N≡N⁺ Cl⁻</p> <p>DO NOT ALLOW —N₂-Cl (covalent bond)</p>

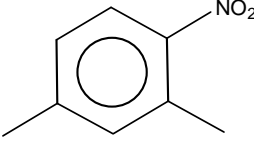
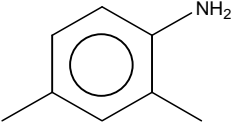
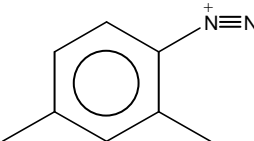
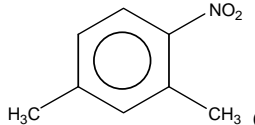
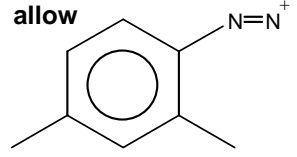
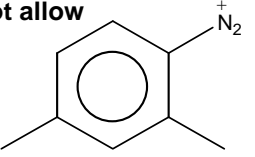
Question	Answer	Mark	Guidance
			<p>ALLOW</p>  <p>IGNORE bond angles</p> <p>DO NOT ALLOW more than one repeat unit unless correct repeat unit is indicated</p> <p>IGNORE brackets with n</p> <p>ALLOW any correct repeat unit</p> <p>ALLOW end bonds shown as - - - -</p> <p>DO NOT ALLOW if structure has no end bonds</p>
	Total	22	

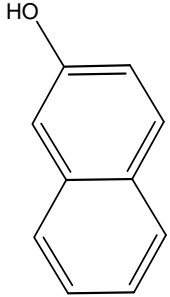
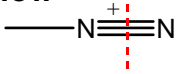
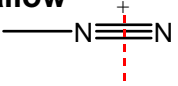
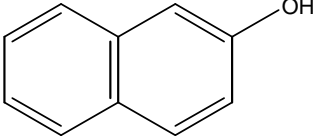
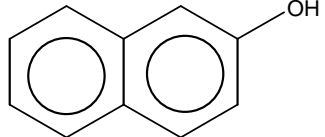
Question		er	Marks	Guidance
2	(a)	<p>In benzene, electrons OR π-bond(s) are delocalised ✓</p> <p>QWC requires delocalised/delocalized spelled correctly and used in correct context</p> <p>In alkenes, π-electrons are OR π-bond is AND localised OR between two carbons ✓</p> <p>benzene has a lower electron density OR alkene/C=C has a higher electron density ✓ <i>Comparison essential</i></p> <p>benzene polarises bromine / Br₂ LESS</p> <p>OR benzene attracts bromine / Br₂ LESS</p> <p>OR benzene induces a weaker dipole in bromine / Br₂ ✓</p>	4	<p>ANNOTATIONS MUST BE USED</p> <p>ALLOW diagram with (π-bond) electrons AND delocalised labelled</p> <p>IGNORE benzene has delocalised structure or ring</p> <p>ALLOW diagram with π-bond labelled ALLOW pi bond for π-bond</p> <p>π-bond OR π-electrons essential for this mark</p> <p>IGNORE charge density DO NOT ALLOW electronegativity</p> <p>ALLOW Br–Br for Br₂ ALLOW electrophile for Br₂</p> <p>ALLOW benzene does NOT polarise bromine / Br₂ OR alkene/C=C polarises Br₂</p> <p>ALLOW benzene does NOT attract bromine / Br₂ OR alkene/C=C attracts Br₂</p> <p>ALLOW benzene does NOT induce dipole in bromine / Br₂ OR alkene/C=C induces dipole in Br₂</p>

Question		er	Marks	Guidance
(b)	(	1	ALLOW correct structural OR displayed OR skeletal formula ALLOW combination of formulae as long as unambiguous
	(ii)	6 ✓	1	NO ECF from (i)
	(iii)	<p>Two of the three structures below with 1 mark for each correct structure ✓✓</p> 	2	ALLOW correct structural OR displayed OR skeletal formula ALLOW combination of formulae as long as unambiguous Structures must clearly show position of Br on benzene ring in relation to side chain ALLOW ECF from (i) if BOTH Br atoms on same carbon on side chain DO NOT ALLOW ECF from (i) if EITHER bromine has been substituted onto the benzene ring
	(iv)	<p>reaction 1: electrophilic addition ✓</p> <p>reaction 2: electrophilic substitution ✓</p>	2	ALLOW electrophile addition ALLOW electrophile substitution ALLOW other phonetic spellings for electrophilic, e.g. electrophylic, etc.
Total			10	

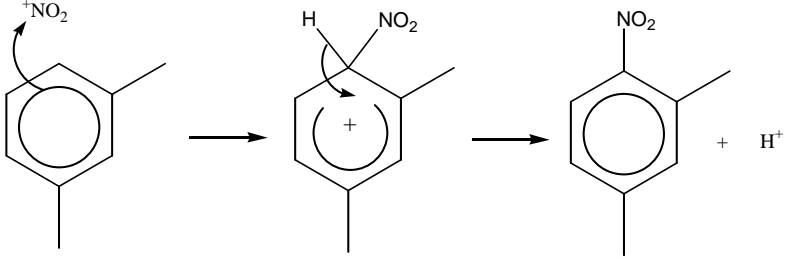
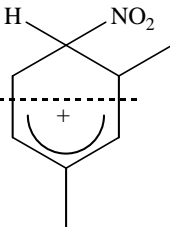
Question	Answer	Mark	Guidance
3 (a)	<p>$\text{AlCl}_3 + \text{Cl}_2 \longrightarrow \text{AlCl}_4^- + \text{Cl}^+ \checkmark$</p>  <p>curly arrow from π-bond to Cl^+ \checkmark</p> <p>correct intermediate \checkmark</p> <p>curly arrow from C-H bond back to reform π-ring \checkmark</p> <p>correct products \checkmark</p> <p>$\text{H}^+ + \text{AlCl}_4^- \longrightarrow \text{AlCl}_3 + \text{HCl} \checkmark$</p> <p>Note: 1st curly arrow should start within the ring or on the ring</p> <hr/> <p>Note: ALLOW mechanism using Kekulé structures:</p> 	6	<p>ANNOTATIONS MUST BE USED</p> <p>DO NOT ALLOW the following intermediate:</p>  <p>π-ring must be more than 1/2 way up AND 'horseshoe' the right way up, ie gap towards C with Cl</p> <p>ALLOW + sign anywhere inside the 'hexagon' of intermediate</p> <p>ALLOW 1st curly arrow starting within the hexagon</p> <p>ALLOW mechanism with $\text{Cl}-\text{Cl} \cdots \text{AlCl}_3$ for 1st 2 marks, ie</p>  <p>Second curly arrow to either $-\text{Cl}$ or AlCl_3</p> <p>Note: If Br^+ is used, DO NOT ALLOW 1st mechanism mark but all other marks available by ECF</p>

Question		er	Mark	Guidance
(b)	(i)	 <p>2 <chem>c1ccc(Cl)cc1</chem> + <chem>ClC(Cl)(Cl)C=O</chem></p> <p>↓</p> <p>+ <chem>H2O</chem></p> <p>1st mark: reactants, correctly balanced, ✓ ie <chem>2 C6H5Cl + Cl3CCHO</chem></p> <p>2nd mark: product, (correctly balanced) ✓ ie <chem>H2O</chem></p>	2	<p>Each mark is independent of the other</p> <p>ALLOW <chem>C6H5Cl</chem> for chlorobenzene</p> <p>ALLOW any unambiguous structure for <chem>Cl3CCHO</chem>, e.g. <chem>CCl3CHO</chem> BUT DO NOT ALLOW <chem>CCl3COH</chem></p> <p>Standalone mark</p> <p>Standalone mark</p>
	(ii)	6 ✓	1	
(c)		<p>substitution/nitration/<chem>NO2</chem> at different positions (on the ring) OR forms different isomers OR multiple substitution/nitration ✓</p>	1	<p>ALLOW examples, e.g. 1-chloro-2-nitrobenzene and 1-chloro-3-nitrobenzene ALLOW 'it' for nitro group</p> <p>ALLOW examples, e.g. 1-chloro-2,3-dinitrobenzene IGNORE nitrate/<chem>NO3</chem></p>
(d)		<p>In phenol, (lone) pair of electrons on O is (partially) delocalised into the ring ✓ QWC: delocalised/delocalized/delocalise, etc must be spelt correctly in the correct context for benzene OR phenol at least once</p> <p>electron density increases/is high ✓ ORA</p> <p><chem>Cl2</chem>/electrophile is (more) polarised ✓ ORA</p>	3	<p>ANNOTATIONS MUST BE USED</p> <p>ALLOW diagram to show movement of lone pair into ring but delocalised ring must be mentioned ALLOW lone pair of electrons on O is (partially) drawn/ attracted/pulled into delocalised ring IGNORE 'activates the ring'</p> <p>DO NOT ALLOW charge density or electronegativity</p> <p>ALLOW <chem>Cl2</chem> is (more) attracted OR <chem>Cl2</chem> is not polarised by benzene OR induces dipoles (in chlorine/electrophile)</p>
Total			13	

Question		Expected Answers	Marks	Additional Guidance
4	a	<p>Bond length intermediate between/different from (short) C=C and (long) C-C ✓</p> <p>ΔH hydrogenation less exothermic than expected (when compared to ΔH hydrogenation for cyclohexene) ✓</p> <p>Only reacts with Br₂ at high temp or in presence of a halogen carrier / resistant to electrophilic attack ✓</p> <p>Please annotate, use ticks to show where marks are awarded</p>	3	<p>ALLOW all carbon-carbon bonds the same length</p> <p>ALLOW ΔH hydrogenation less (negative) than expected</p> <p>ALLOW ΔH hydrogenation different from that expected</p> <p>DO NOT ALLOW ΔH halogenation/hydration</p> <p>ALLOW doesn't decolourise/react with/polarise Br₂</p> <p>ALLOW doesn't undergo addition reactions (with Br₂)</p>
	b	<p>i</p> <p>compound A</p>  <div style="border: 1px solid black; padding: 5px; display: inline-block; margin-left: 10px;"> <p>if NO₂ in wrong position penalise here and ECF for rest of b(i) and b(ii)</p> </div> <p style="text-align: right;">✓</p> <p>compound B</p>  <p style="text-align: right;">✓</p> <p>compound C</p>  <p style="text-align: right;">✓</p>	4	<p>ALLOW any 4-nitro-1,3-dimethylbenzene drawn in any orientation</p> <p>ALLOW</p>  <p>drawn in any orientation</p> <p>ALLOW any 4-amino-1,3-dimethylbenzene drawn in any orientation</p> <p>ECF amine of incorrect compound A (e.g. position of NO₂ or lack of methyl sticks/groups)</p> <p>ALLOW diazonium chloride salt of 1,3-dimethylbenzene</p> <p>ECF diazonium salt/compound of incorrect compound B</p> <p>IGNORE Cl⁻ ion</p> <p>allow</p>  <p>not allow</p> 

Question	Expected Answers	Marks	Additional Guidance
	<p>compound D</p> 	✓	<p>ALLOW if + charge is floating between the two Ns only if it is closer to the correct N</p> <p>allow</p>  <p>not allow</p>  <p>ALLOW any of</p>   <p>ALLOW O⁻ in place of OH</p>

If NO₂ is in correct position do not penalise even if compound A in b(i) is not in correct position

Question	Expected Answers	Marks	Additional Guidance
ii	<p>mark 1 $\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_3\text{O}^+ + 2\text{HSO}_4^- + \text{NO}_2^+ \checkmark$</p> <p>mark 2 – curly arrow from π ring to $^+\text{NO}_2 \checkmark$</p> <p>mark 3 – intermediate with π ring broken in the correct place \checkmark</p> <p>mark 4 – curly arrow from C–H bond back to reform π ring AND correct products \checkmark</p> <p>mark 5 - $\text{H}^+ + \text{HSO}_4^- \rightarrow \text{H}_2\text{SO}_4 \checkmark$</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p>Link to compound A in part (i) – cannot score full marks [in b(i) & b(ii)] if NO₂ is not adjacent to a methyl</p> </div> 	5	<p>Equation to show formation of NO₂⁺ ion \checkmark ALLOW $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{O} + \text{HSO}_4^- + \text{NO}_2^+$ $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{HSO}_4^- + \text{H}_2\text{NO}_3^+ \rightarrow \text{H}_2\text{O} + \text{NO}_2^+$</p> <p>ALLOW mark 2 curly arrow must be from 1,3-dimethylbenzene to NO₂⁺ and ECF for marks 3 and 4</p> <p>DO NOT ALLOW intermediate</p>  <p>ALLOW CH₃s shown</p> <p>ALLOW $\text{H}_3\text{O}^+ + \text{HSO}_4^- \rightarrow \text{H}_2\text{O} + \text{H}_2\text{SO}_4$</p>
iii	2 \checkmark	1	No other correct response
Total		13	