

Mark Scheme for Mock Prelim Paper 2

Mark Scheme Abbreviations

;	separate marking points (1 marking point is 0.5 marks, unless stated otherwise)
R	reject
I	ignore
COND	mark awarded is conditional on previous marking point
OWTTE	or words to that effect (accept other ways of expressing the same idea)
<u>underline</u>	actual word given must be used by candidate (grammatical variants accepted)
()	the word / phrase in brackets is not required
ORA	or reverse argument

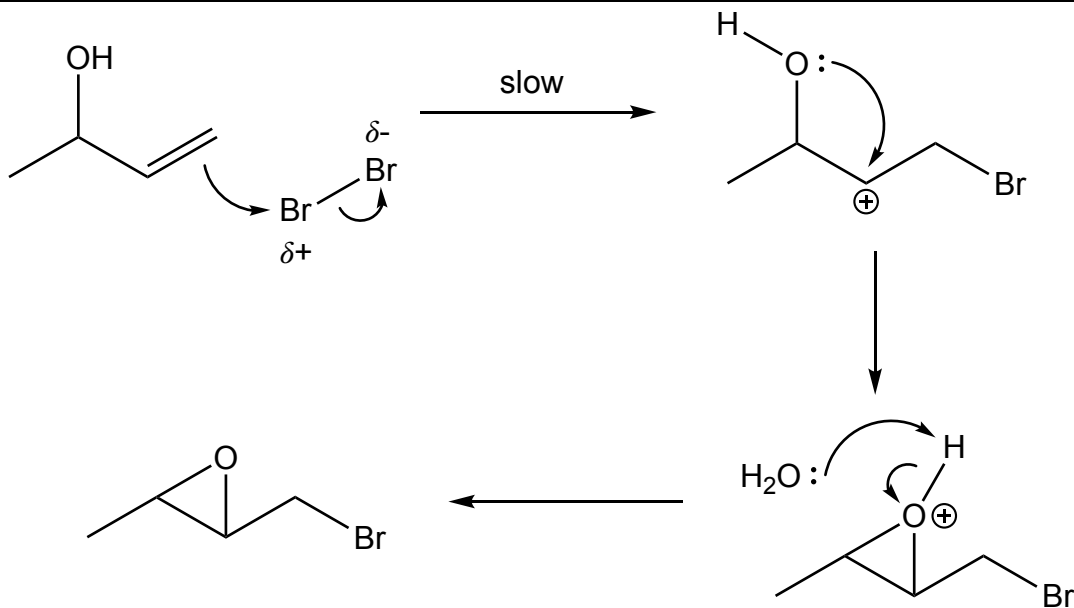
Question			Answer	Guidance
1	a	i	<p>giant metallic structure / lattice;</p> <p>sea of delocalised electrons AND Cs⁺ cations (arranged in a lattice);</p> <p><u>electrostatic attraction / electrostatic forces of attraction</u> (known as metallic bonding);</p> <p>between electrons and Cs⁺ cations;</p> <p>R metallic bonding</p>	Candidates are expected to explain the origin of metallic bonding, because the word 'metallic' does not give any insight into the bonding present.
		ii	<p>Li has <u>stronger</u> metallic bonding than Cs;</p> <p>because charge density of Li⁺ cation is higher than that of Cs⁺ cation;</p> <ul style="list-style-type: none"> • Li is harder to vapourise than Cs <p>Pb has <u>more</u> valence electrons than Cs;</p> <p>because Pb is in Group 14, while Cs is in Group 1;</p> <ul style="list-style-type: none"> • Pb has more active electrons than Cs <p>Answers missing either one of the bullet points will be deducted 0.5m.</p> <p>The total number of marks awarded must be non-negative.</p>	
	b	i	$E^\ominus(\text{Li}^+/\text{Li}) = -3.04 \text{ V}$ AND $E^\ominus(\text{Na}^+/\text{Na}) = -2.71 \text{ V}$ AND $E^\ominus(\text{K}^+/\text{K}) = -2.92 \text{ V}$;	

		<p>inconsistent reducing power down the group OR reducing power is approximately invariant / constant OR reducing power remains strong; OWTTE</p>	
	ii	<p>number of principal quantum shells increases down the group;</p> <p>valence electron is further AND less attracted to the nucleus; OWTTE</p> <p>1st ionisation energy decreases down the group (The conclusion must be present. Deduct 0.5m for no conclusion. No marks awarded for this question for wrong conclusion.)</p> <p>The total number of marks awarded must be non-negative.</p>	
c	i	<p>$\text{Cs} + \text{H}_2\text{O} \rightarrow \text{Cs}^+ + 0.5 \text{H}_2 + \text{OH}^-$ reaction has $E_{\text{cell}} > 0$; OWTTE</p> <p>because Group 1 metals have $E^\ominus(\text{X}^+/\text{X})$ around -3 V / more negative than -2 V which is more negative than $E^\ominus(\text{H}_2\text{O}/\text{H}_2) = -0.83 \text{ V}$; OWTTE</p> <p>Cs metal will react with water (spontaneously) to form Cs^+ ions;</p> <p>unable to maintain $[\text{Cs}^+] = 1 \text{ mol dm}^{-3}$ OR cannot place Cs in water;</p>	<p>The reduction potential of Cs^+/Cs is not given in the Data Booklet, so it is the job of the candidate to offer further insight of what they would expect this value to be.</p>
	ii	<p>M1 for amount of electrons</p> $n_{e^-} = \frac{It}{F} = \frac{2.00 \times 48 \times 60 \times 60}{96500} = 3.5813 \text{ mol}$ <p>A1 for correct answer</p> $\text{mass} = 3.5813 \times 132.9 = 476 \text{ g}$	

	d		<p>Award 1 mark for 3 points. Award 2 marks for 5 points.</p> <ul style="list-style-type: none"> • down Group 1, the charge density of the cation decreases (because ionic radius increases down the group) • polarising power of the cation weakens / decreases down the group • electron cloud of peroxide ion is less distorted / polarised down the group • more energy required to break the O—O bond in the peroxide ion down the group • decomposition temperature increases down the group 	
2	a	i	<p>intermediate B cannot be the intermediate because;</p> <p>the C=C bond in B is non-polar / C atoms have same electronegativity (pi electrons in the C=C bond are localised);</p> <p>so there is no electron deficient / electrophilic site in the C=C bond in B;</p> <p>NaBH₄ cannot perform a nucleophilic attack on the C=C bond;</p> <p>OR</p> <p>C=C bond is electron-rich;</p> <p>and will repel / prevent;</p>	<p>Both A and B are produced, but the question is asking you which of them is the <i>intermediate</i>. The candidate should argue why B is NOT the intermediate (and why A is). Because A and B are produced, there is no value in arguing why A is produced. Why A can react is also a given, so full credit is given to candidates that argue why</p>

		<p>the electron-rich nucleophile NaBH_4 from reacting with B further;</p> <p>an explanation on why A is produced will only gain max. 1m</p>	B cannot react with NaBH_4 .
	ii	<p>The following tests are acceptable:</p> <p>To separate test tubes containing A and B</p> <p><u>Test 1</u></p> <p>add 2,4-DNPH;</p> <p>orange precipitate observed for A, but no precipitate is formed for B;</p> <p><u>Test 2</u></p> <p>add KMnO_4 AND $\text{H}_2\text{SO}_4(\text{aq})$ OR $\text{NaOH}(\text{aq})$ (then heat);</p> <p>purple solution remains for A, solution decolourises for B;</p> <p><u>Test 3</u></p> <p>add $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ AND $\text{H}_2\text{SO}_4(\text{aq})$ AND heat / warm;</p> <p>orange solution remains for A, orange solution decolourises / turns green for B;</p> <p><u>Test 4</u></p> <p>add $\text{Br}_2(\text{aq})$ OR $\text{Br}_2(l)$ OR Br_2 in CCl_4;</p>	

		<p><u>orange</u> solution remains for A, solution decolourises for B; (for aqueous Br₂ used) <u>brown</u> solution remains for A, solution decolourises for B; (for pure or organic Br₂ used)</p> <p><u>Test 5</u></p> <p>add Na(s) OR any group 1 metal;</p> <p>no effervescence observed for A, effervescence observed for B;</p>	
	iii	<p>equal probability of the borohydride nucleophile from attacking the top and bottom of the plane with respect to the trigonal planar geometry of the carbonyl carbon;</p> <p>which forms equal proportions of butan-2-ol enantiomers (and their rotating power cancels each other);</p>	
	iv	<p>H₂(g), high pressure, Ni (catalyst); (award 1m for this marking point, catalyst must be present)</p> <ul style="list-style-type: none"> • room temperature condition not needed <p>accept other catalysts such as Pd/C (palladium on carbon), Pt</p>	
b	i	<p><u>electrophilic addition</u>; (1m is awarded)</p>	



all partial charges, formal charges indicated;

slow step correctly identified;

all curly arrows correct;

correct final product;

ii test tube **Y** (no marks awarded for writing test tube **X** as the answer)

the pi-electrons in the C=C bond are delocalised in the C=C—C=O system;

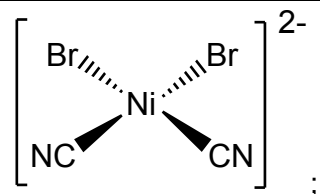
since O is more electronegative than C, the electron density in the C=C bond decreases **OR** C=C bond is less electron rich (because electron density will be richer towards O);

		<p>but in Y, the pi electrons in the C=C bond is localised OR not delocalised; OWTTE</p> <p>so the C=C bond is more electron-rich in B than that in 3-oxybut-1-ene;</p> <p>and will attack Br₂ faster</p>	
3	a	1s ² 2s ² 2p ⁶ 3s ² 3p ⁶ 3d ⁶ ; (1m or 0m awarded)	
	b	<p>in an octahedral ligand field;</p> <p>the d-orbitals split;</p> <p>into 2 different energy levels;</p> <p>an electron transitions / is excited / is promoted to a higher-energy level (known as d-d transition);</p> <p>wavelength / frequency of light <u>absorbed</u>;</p> <p>colour seen / observed / reflected / transmitted is <u>complement of colour</u> absorbed;</p>	
	c	<p>when a system <u>at dynamic equilibrium</u> experiences a <u>change in conditions</u>, the <u>position of equilibrium</u> will <u>shift</u> so as to <u>reduce</u> OR <u>counteract</u> OR <u>lessen</u> that change; (1m or 0m awarded)</p> <p>R eliminate, stop</p>	
	d	<p>aqueous ammonia is basic / contains OH⁻ ;</p> <p>addition of NH₃(aq) causes concentration of OH⁻ to increase, causing position of equilibrium 1 to shift right forming green precipitate of Ni(OH)₂ ;</p>	

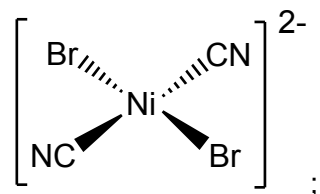
further addition of $\text{NH}_3(\text{aq})$ increases the concentration of NH_3 causing the position of equilibrium 2 to shift right forming blue complex of $\text{Ni}(\text{NH}_3)_6^{2+}$;

this decreases the concentration of Ni^{2+} which causes position of equilibrium 1 to shift left so the green precipitate redissolves (to form Ni^{2+});

e



cis isomer labelled; **COND**



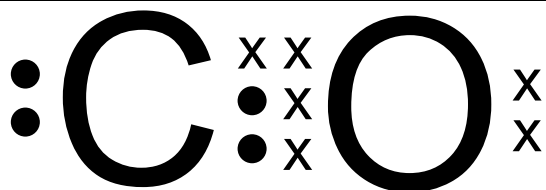
trans isomer labelled; **COND**

R tetrahedral complexes

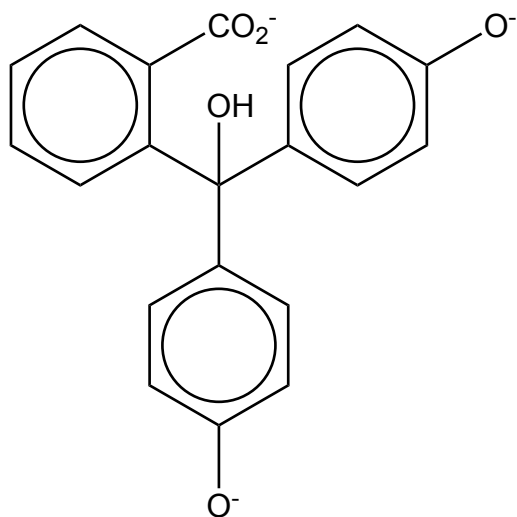
f

i

Award 1m or 0m for this question.

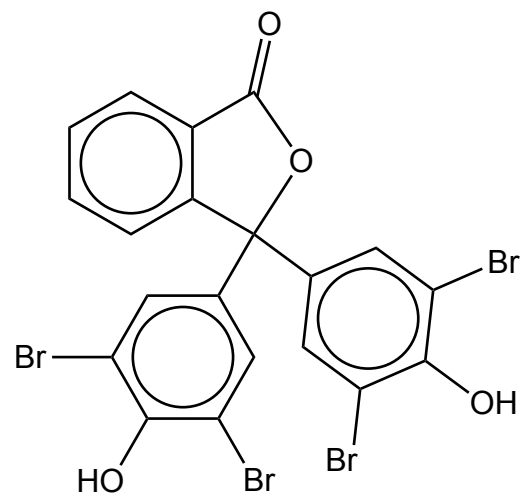


		ii	<p>CO produced is <u>poisonous</u>;</p> <p>and will irreversibly bind with haemoglobin which will deprive the body of vital oxygen; OWTTE</p> <p>R toxic</p>	
4	a	i	condensation OR electrophilic (aromatic) substitution; (award 1m or 0m)	
		ii	<p><u>Hot NaOH(aq)</u></p> <p>hydrolysis products correct (both carboxylate ion AND alcohol);</p> <p>both phenols deprotonated;</p>	



excess $\text{Br}_2(\text{aq})$

Award 1m or 0m for this box.



	b	i	$\text{CO}_2 + 2 \text{OH}^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$ (award 1m or 0m)	
		ii	<p>ammonia is a weak base;</p> <p>the concentration of OH^- is not high enough for the phenolphthalein indicator to exist in its violet/pink form;</p> <p>hence dilute ammonia is not suitable to be used as a base for "disappearing ink"</p> <p>award 0m if the candidate states dilute ammonia is suitable</p> <p>R explanations that ammonia reacts too slowly with CO_2, or that CO_2 is a weak acid</p>	
		iii	<p>M1 for calculating $[\text{CO}_3^{2-}]$ and $K_b(\text{CO}_3^{2-})$ $[\text{CO}_3^{2-}] = 0.5 \times 10^{-3} = 0.000500 \text{ mol dm}^{-3}$</p> <p>$K_b(\text{CO}_3^{2-}) = 10^{10.3 - 14} = 1.9953 \times 10^{-4} \text{ mol dm}^{-3}$</p> <p>MA1 for final calculations</p> $[\text{OH}^-] = \sqrt{1.9953 \times 10^{-4} \times 0.000500} = 3.1585 \times 10^{-4} \text{ mol dm}^{-3}$ <p>pH = 10.5</p>	
		iv	<p>M1 for $[\text{HIn}] + [\text{In}^-]$ and obtaining the ratio of $\frac{[\text{HIn}]}{[\text{In}^-]}$ (or the reciprocal)</p> $[\text{HIn}] + [\text{In}^-] = \frac{0.01}{318.3 \times \frac{100}{1000}} = 0.00031417 \text{ mol dm}^{-3}$	

$$\frac{[\text{HIn}]}{[\text{In}^-]} = \frac{[\text{H}^+]}{K_a} = \frac{10^{-8.5}}{10^{-9.3}} = 6.3096$$

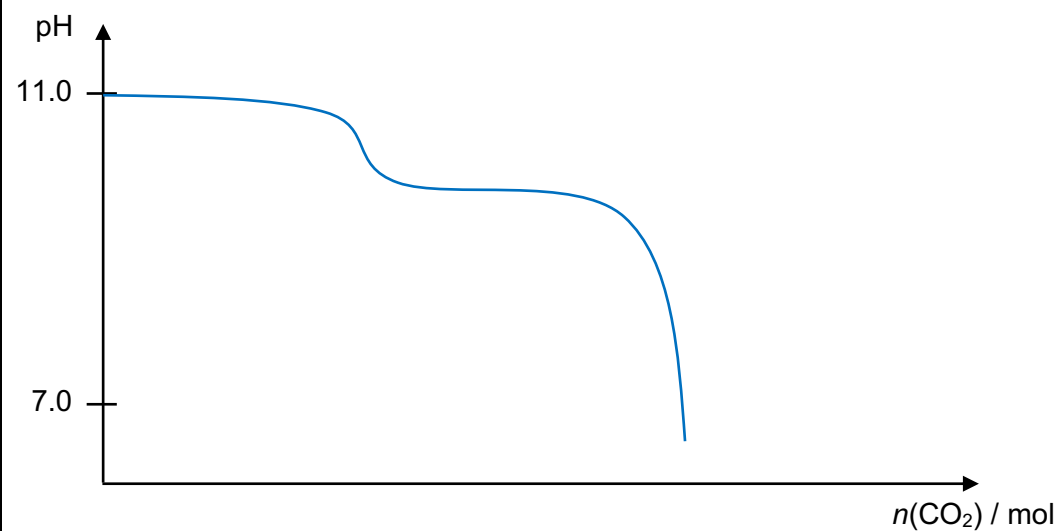
MA1 for solving for $[\text{In}^-]$ (no ecf)

$$(1 + 6.3096) [\text{In}^-] = 0.00031417 \text{ mol dm}^{-3}$$

$$[\text{In}^-] = 4.30 \times 10^{-5} \text{ mol dm}^{-3} < 2.0 \times 10^{-4} \text{ mol dm}^{-3}$$

the sample of disappearing ink is effective

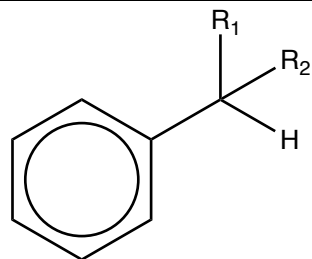
v

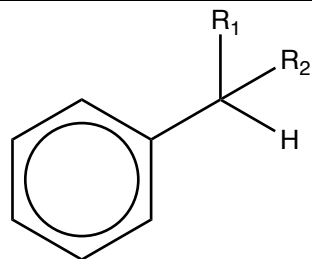


[G1] mark for the shape of the graph (award 1m or 0m)

- correct shape (slight sharp decrease at first equivalence point, big sharp decrease at second equivalence point).
- ending pH is near 7 (above pH 7 is acceptable)

			<ul style="list-style-type: none"> ending of graph must be a sharp downturn 	
		vi	<p>thymolphthalein;</p> <p>the ink colour is blue;</p> <p>accept: cresolphthalein; the corresponding ink colour is purple/violet;</p>	At the "acidic" range, the indicator must be colourless.
5	a	i	<p>correct axes and vertical intercept labelled;</p> <p>indicates constant half-life; (award 1m for this marking point)</p> <p>labels essential concentrations which reader can deduce half-lives;</p>	
		ii	<p>graph shows second half-life twice of first half-life with appropriate labels; (award 1m for this marking point)</p> <p>Candidates missing marking points in part (i) may be awarded the relevant credit in this question, with the marks awarded to part (i)</p>	
		b	<p>addition reactions will <u>destroy</u> / <u>disrupt</u> the aromaticity;</p> <p>and to do so takes a lot of energy / energetically unfavourable / high activation energy / a (much) more unstable addition product;</p>	
		c	<p>$M_r = 132$, so H has 10 carbons and 12 hydrogens; (need not be explicitly written out, but structure must have 10 carbons and 12 hydrogens)</p>	



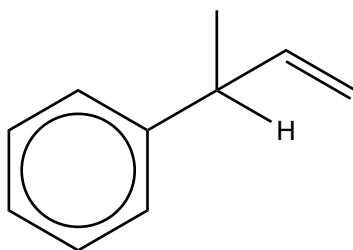
concludes that the structure must be in the form of  where R_1 and R_2 are groups to be determined (R_1 and R_2 may be the same as a $C=C$ double bond will undergo oxidative cleavage);

mentions oxidative cleavage;

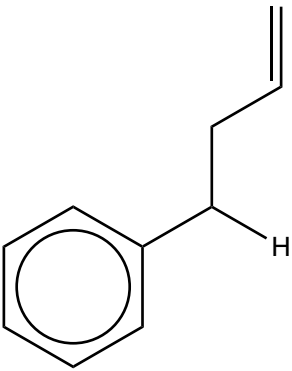
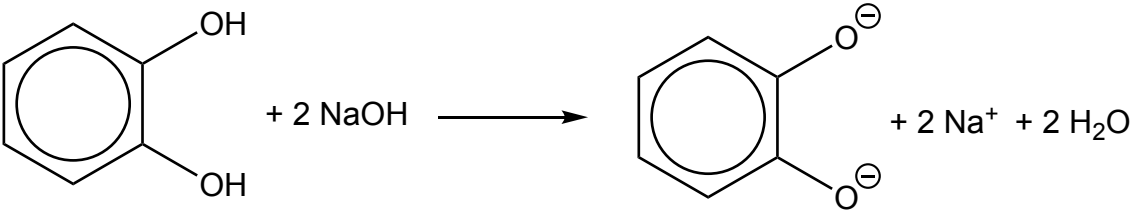
mentions side-chain oxidation;

concludes that $C=C$ bond is terminal;

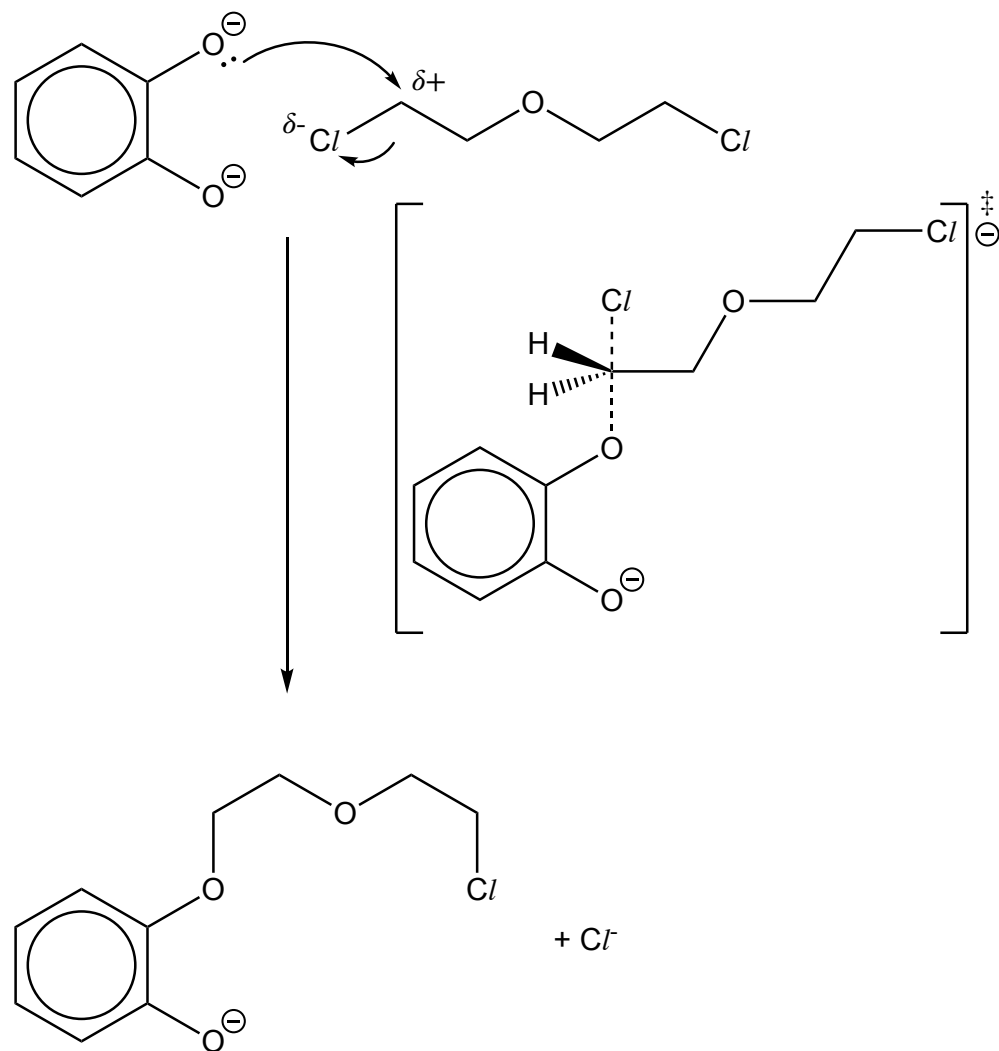
identifies

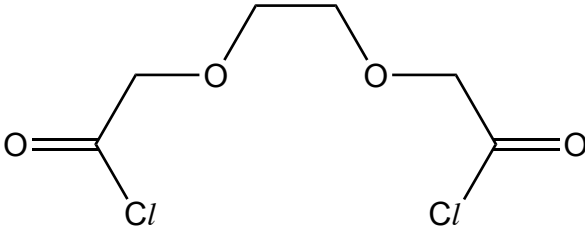


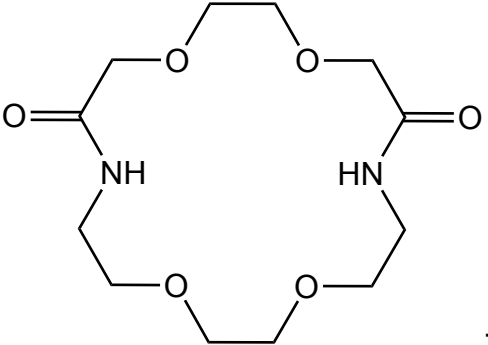
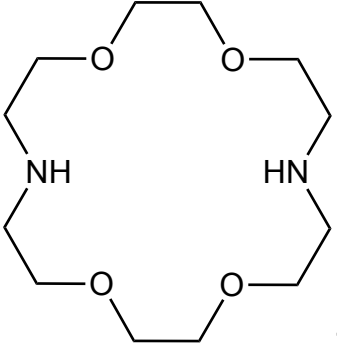
;
both enantiomers of the structure drawn;

			<p>identifies</p>  <p>;</p>	
6	a	i	<p>unfavourable ion-induced dipole interactions between ions and solvent molecules releases little energy;</p> <p>to overcome the strong ionic bonds between K^+ and MnO_4^- ions;</p>	
		ii	<p>acid-base exchange shown (mono-deprotonation acceptable); (award 1m for this marking point)</p> <ul style="list-style-type: none"> • curly arrows are NOT required  <p>S_N2 mechanism drawn;</p> <p>partial charges with correct curly arrows;</p> <p>transition state drawn; (award 1m for this marking point)</p>	

correct intermediate(s);



			understanding of multiple substitutions indicated;	
		iii	lone pair of the protonated phenol is less available / protonated phenol is a weaker nucleophile; because the lone pair is delocalised into the benzene ring;	
		iv	deduces B has chlorine; mole ratio leading to empirical formula $C_3H_4O_2Cl$; (award 1m for this marking point) correct molecular formula $C_6H_8O_4Cl_2$; correct structure of B ; (award 1m for this marking point) 	
		v	any 2 of the following: PCl_5 ; PCl_3 ; $SOCl_2$;	

		<p>vi 1m for each of C and D</p> <p>C</p>  <p>;</p> <p>D</p>  <p>;</p>	
		<p>vii amine X may react with 2 different molecules of B; a large volume of an appropriate solvent dilutes B and X OR lowers the concentration of B and X;</p>	<p>The candidate needs to display understanding that the byproduct(s) are formed through an intermolecular reaction,</p>

		<p>so that it is less probable for X to react with 2 different molecules of B due to the lower frequency of effective intermolecular collisions;</p> <p>so after 1 molecule of B reacts with X, the resultant intermediate will be more likely to undergo an intramolecular reaction to form C instead;</p>	<p>while the desired product will be formed from an intramolecular reaction.</p>
	b	<p>Na⁺ for the top box;</p> <p>K⁺ for the bottom box;</p>	<p>From the data booklet, the radius of Na⁺ is 95 pm, so its diameter is 190 pm which falls between the range of 170 and 220 ppm. For K⁺, we expect the radius to be less than 181 pm (Cl⁻) but more than 99 pm (Ca²⁺). This radius is the best fit for the range of diameter 260 to 320 pm (radius from 130 to 160 pm).</p>
	c	<p>i circles all O atoms only; (award 1m for this marking point)</p> <p><u>8</u> hydrogen bonds; (award 1m for this marking point)</p>	
		<p>ii chemical shift of 4.82 only appears when a mixture of PhH and PhF is used;</p> <p>which must be attributed to 1 molecule of PhH and PhF each being encapsulated (because the other 2 chemical shifts are attributed to 2 molecules of PhH and PhF are, separately, encapsulated);</p>	
		<p>iii the encapsulation process has a positive entropy change;</p>	

		<p>because the encapsulation of 1 molecule of AdA results in 2 benzene molecules being released;</p>	
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so there is a net increase in the number of free molecules (resulting in more disorder);

$$\Delta G = \Delta H - T\Delta S;$$

hence, the gradient of the graph is negative;

this line is **Y**;