

**Section A (multiple choice)**

Question Number	Correct Answer	Mark
<b>1 (a)</b>	D	<b>1</b>

Question Number	Correct Answer	Mark
<b>1 (b)</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>1 (c)</b>	A	<b>1</b>

Question Number	Correct Answer	Mark
<b>2</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>3</b>	D	<b>1</b>

Question Number	Correct Answer	Mark
<b>4 (a)</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>4 (b)</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>4 (c)</b>	A	<b>1</b>

Question Number	Correct Answer	Mark
<b>5 (a)</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>5 (b)</b>	D	<b>1</b>

Question Number	Correct Answer	Mark
<b>5 (c)</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>6</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>7</b>	A	<b>1</b>

Question Number	Correct Answer	Mark
<b>8</b>	B	<b>1</b>

Question Number	Correct Answer	Mark
<b>9 (a)</b>	A	<b>1</b>

Question Number	Correct Answer	Mark
<b>9 (b)</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>9 (c)</b>	D	<b>1</b>

Question Number	Correct Answer	Mark
<b>10</b>	C	<b>1</b>

Question Number	Correct Answer	Mark
<b>11</b>	D	<b>1</b>

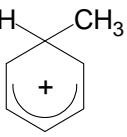

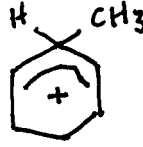
Question Number	Correct Answer	Mark
<b>12</b>	C	<b>1</b>

**TOTAL FOR SECTION A = 20 MARKS**

## Section B

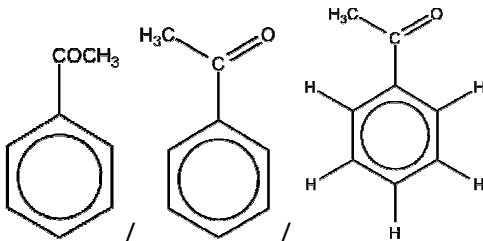
Question Number	Acceptable Answers	Reject	Mark
<b>13</b> <b>(a)(i)</b>	CH <sub>3</sub> Cl / CH <sub>3</sub> Br / CH <sub>3</sub> I Ignore name and state symbols  Allow displayed formula	Name alone	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13</b> <b>(a)(ii)</b>	CH <sub>3</sub> Cl + AlCl <sub>3</sub> → CH <sub>3</sub> <sup>+</sup> + AlCl <sub>4</sub> <sup>-</sup> Allow CH <sub>3</sub> <sup>δ+</sup> AlCl <sub>4</sub> <sup>δ-</sup> and other halogens  Ignore state symbols and curly arrows	CH <sub>3</sub> <sup>δ+</sup> -AlCl <sub>3</sub> <sup>δ-</sup> + Cl <sup>-</sup>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13</b> <b>(a)(iii)</b>	 <p>Ignore curly arrows and use of wedges/dashes</p> <p>Ignore attempts to complete mechanism if intermediate is correct</p> <p>Must show reasonable delocalisation over at least 3 carbon atoms</p> <p>Allow positive charge anywhere inside benzene ring</p> <p>Allow delocalization shown as dashed line e.g.</p>  <p>Allow correct Kekulé structure</p>	<p>Complete circle of delocalization</p> <p>'Upside down' delocalization e.g.</p> 	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13</b> <b>(b)(i)</b>	(Methyl group) donates/increases electron density to the ring/feeds electrons into ring  Allow the methyl group is electron releasing	Donates <b>lone</b> pair of electrons Ring becomes more electronegative Just 'inductive effect'	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13 (b)(ii)</b>	(Methylbenzene) is more susceptible to electrophilic attack/attack by <b>positive</b> species/makes it a stronger nucleophile  Ignore comments about ring stability  Allow methyl group stabilizes carbocation		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13 (c)(i)</b>	 $\text{C}_6\text{H}_5\text{COCH}_3$ / Allow displayed or skeletal formulae or Kekulé		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13 (c)(ii)</b>	<b>Any 2 from 4</b> Lower energy input (to heat reaction)/less heat losses/more efficient heating <b>(1)</b>  Electrical energy can be obtained from renewable resources whereas gas is non renewable <b>(1)</b>  Easier separation of catalyst/(easier to) re-use catalyst <b>(1)</b>  Involves less chlorine/chlorine compounds <b>(1)</b>  Ignore any comments regarding carbon dioxide level/global warming	Faster reaction because using a catalyst Just 'uses less fuel'         Just uses less toxic/harmful chemicals	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13 (d)</b>	Fuming sulfuric acid / oleum / sulfur trioxide (dissolved) in concentrated sulfuric acid  Allow fuming $\text{H}_2\text{SO}_4$ / $\text{H}_2\text{S}_2\text{O}_7$ / $\text{SO}_3$ (dissolved) in concentrated $\text{H}_2\text{SO}_4$	Just sulfuric acid or sulfur trioxide	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(a)(i)</b>	Conc. Nitric acid <b>(1)</b>  Conc. Sulfuric acid <b>(1)</b> Allow correct formulae  Ignore state symbols Sulfuric acid and nitric acid with no mention of concentrated scores <b>(1)</b>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(a)(ii)</b>	Pear shaped/round bottomed flask & heat source <b>(1)</b> Allow vertical arrow with or without the word heat Allow water bath as a heat source  Liebig condenser, shown vertically <b>(1)</b>  (Water) flow shown correctly into a jacket <b>(1)</b>  Ignore thermometers unless stoppered  Penalise (one for each): Stopper/sealed Gaps between flask and condenser Condenser inner tube extends into liquid in flask	Conical flask in diagram or label	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(a)(iii)</b>	Heat Speed up reaction / to overcome the activation energy / provide energy to break bonds / because activation energy for the reaction is high <b>(1)</b>  Under reflux Prevent escape of reactants / products Or As they may be flammable / harmful / volatile <b>(1)</b>	Just to provide energy for the reaction to start     Just to increase the yield/make reaction go to completion	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(a)(iv)</b>	HOCH <sub>2</sub> CH <sub>2</sub> N(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> Allow OHCH <sub>2</sub> CH <sub>2</sub> N(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub>  Allow displayed or skeletal formulae		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(a)(v)</b>	Reduction <b>(1)</b> Allow redox  Tin / iron / zinc <b>and</b> (conc./dilute) hydrochloric acid <b>(1)</b> Accept correct names or formulae for both alternatives  Ignore references to tin as a catalyst Ignore conditions  Allow NaBH <sub>4</sub> in alkali (Pd catalyst)	Addition of NaOH unless clearly after the reduction Hydrogen gas and nickel (catalyst) LiAlH <sub>4</sub>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(b)(i)</b>	Moles of 2-hydroxy benzoic acid = 9.4/138 <b>(1)</b> (= 0.0681)  So theoretical yield of aspirin = 0.0681 x 180 <b>(1)</b> = 12.26 g  % yield = 100 x 7.77/12.26 = 63.4% <b>(1)</b>  Or  Moles of 2-hydroxy benzoic acid = 9.4/138 <b>(1)</b> (= 0.0681)  Moles of aspirin = 7.77/180 <b>(1)</b> (=0.0432) % yield = 100 x 0.0432/0.0681 = 63.4/63% <b>(1)</b>  Correct answer with no working 3 marks  Allow 1 max. if Mr values are transposed 108%	100 x 7.77/9.40 = 82.7%	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>*(b)(ii)</b>	Dissolve/add to impure solid in min. volume / amount <b>(1)</b> of hot solvent / water <b>(1)</b> (Filter whilst hot) Allow to cool <b>and</b> filter off product / (re)crystallize <b>and</b> filter off product <b>(1)</b> Wash with cold / small amount of solvent / water (then dry) <b>(1)</b>	Just 'small/little amount of water'  Named solvents other than water – penalise once	<b>4</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(b)(iii)</b>	It reduces yield as some product remains in solution Allow stated and explained errors due to transfer e.g. left on filter paper	Just 'transfer errors'	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(c)(i)</b>	CH <sub>3</sub> COCl / (CH <sub>3</sub> CO) <sub>2</sub> O / ethanoyl chloride / ethanoic anhydride  If both name and formula are given then both must be correct  Allow acetyl chloride / acetic anhydride  Ignore any additional information  Allow displayed formulae	Ethanoic acid	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(c)(ii)</b>	(Lessen) risk of overdose / as paracetamol is toxic in larger doses/ as paracetamol is harmful in larger doses / reduce risk of taking medication over a longer time period than necessary / reduce risk of addiction		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>14</b> <b>(c)(iii)</b>	Net forces between paracetamol and water are less than the forces between water and water and / or paracetamol and paracetamol  Allow benzene / ring doesn't interact with water  Allow benzene ring is hydrophobic / non polar / only forms London forces / can't form hydrogen bonds	Just paracetamol / benzene ring is large / steric hindrance	<b>1</b>



Question Number	Correct Answer	Mark
15	A	1

Question Number	Correct Answer	Mark
16	C	1

Question Number	Correct Answer	Mark
17	B	1

Question Number	Correct Answer	Mark
18	A	1

Question Number	Correct Answer	Mark
19	D	1

Question Number	Correct Answer	Mark
20	B	1

Question Number	Correct Answer	Mark
21	D	1

Question Number	Correct Answer	Mark
22	C	1

Question Number	Correct Answer	Mark
23	A	1

Question Number	Correct Answer	Mark
24	A	1

Question Number	Correct Answer	Mark
25	B	1

Question Number	Correct Answer	Mark
26	B	1

Question Number	Correct Answer	Mark
27	C	1

**Section C**

Question Number	Acceptable Answers	Reject	Mark
28 <b>(a)(i)</b>	$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$ <b>(1)</b> $\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + 4\text{H}^+ + 4\text{e}^-$ <b>(1)</b> Allow multiples Ignore state symbols		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(a)(ii)</b>	$3\text{CH}_3\text{CH}_2\text{OH} + 2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ \rightarrow 3\text{CH}_3\text{COOH} + 4\text{Cr}^{3+} + 11\text{H}_2\text{O}$ Allow hydrogen ions and water molecules not cancelled e.g. $3\text{CH}_3\text{CH}_2\text{OH} + 2\text{Cr}_2\text{O}_7^{2-} + 28\text{H}^+ \rightarrow 3\text{CH}_3\text{COOH} + 4\text{Cr}^{3+} + 11\text{H}_2\text{O} + 12\text{H}^+$ $3\text{CH}_3\text{CH}_2\text{OH} + 2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ + 3\text{H}_2\text{O} \rightarrow 3\text{CH}_3\text{COOH} + 4\text{Cr}^{3+} + 14\text{H}_2\text{O}$ $3\text{CH}_3\text{CH}_2\text{OH} + 2\text{Cr}_2\text{O}_7^{2-} + 28\text{H}^+ + 3\text{H}_2\text{O} \rightarrow 3\text{CH}_3\text{COOH} + 4\text{Cr}^{3+} + 14\text{H}_2\text{O} + 12\text{H}^+$	Equations with electrons	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>* 28</b> <b>(a)(iii)</b>	<p>Moles of thiosulfate = <math>34.40/1000 \times 0.025</math>  <math>= 8.6 \times 10^{-4}</math> (mol) <b>(1)</b></p> <p>So moles <math>I_2 = 4.3 \times 10^{-4}</math> (mol) <b>(1)</b></p> <p>So moles of dichromate unreacted = <math>4.3 \times 10^{-4} / 3</math>  <math>= 1.433 \times 10^{-4}</math> (mol) <b>(1)</b></p> <p>So moles of dichromate reacted with ethanol  <math>= 8 \times 10^{-4} - 1.43 \times 10^{-4} = 6.567 \times 10^{-4}</math> (mol)  <b>(1)</b></p> <p>So moles of ethanol = <math>6.567 \times 10^{-4} \times 3/2</math> mol  <math>= 9.85 \times 10^{-4}</math> (mol) <b>(1)</b></p> <p>Concentration = <math>9.85 \times 10^{-4} / 0.005</math>  <math>= 0.197</math> (mol dm<sup>-3</sup>) <b>(1)</b></p> <p>Correct answer (0.197) with no working 6 marks          Allow 4 max. for missing subtraction in step 4 and gaining answer of 0.043(0)</p>		<b>6</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(a)(iv)</b>	<p><math>0.197 \times 10 = 1.97</math> (mol dm<sup>-3</sup>)          Allow answer to (a) (iii) <math>\times 10</math></p>		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(a)(v)</b>	To prevent other (non volatile) substances (in the drink) from reacting with the dichromate ions		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(a)(vi)</b>	<p>because it allows the ethanol to evaporate (allowing it to mix with the dichromate) <b>(1)</b></p> <p>make sure all ethanol reacts <b>(1)</b></p> <p>Concentration / results would have been lower than the actual value <b>(1)</b></p>		<b>3</b>

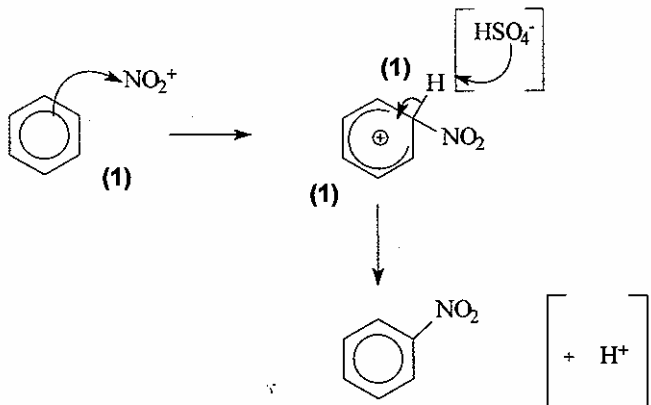
Question Number	Acceptable Answers	Reject	Mark
<b>28</b> <b>(a)(vii)</b>	No, as only one sample titrated so no evidence that results are repeatable / no, as not all the ethanol has evaporated/no, as the dichromate may have reacted with something else/ no, as not all the ethanol has reacted  Allow only 1 titration carried out		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>*</b> <b>(b)(i)</b>	Early breathalysers: (the extent to which) dichromate turns <b>green (1)</b>  Fuel cells: (more alcohol means larger) current / quantity of electricity <b>(1)</b>  Infrared breathalysers: (more alcohol means greater) absorbance <b>(1)</b>  Ignore reference to specific bonds provided they are present in ethanol	Just colour change  Just 'potential difference measured' Just 'voltage measured'  Just 'gives a peak'	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(b)(ii)</b>	Water (in the breath) also has an OH bond  Allow other named molecules on the breath provided they have an OH bond		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(b)(iii)</b>	Additional evidence is more reliable  Or Police often use IR as well as fuel cell breath test to provide sufficient evidence to prosecute (without need for blood test)  Or Fuel cell breathalysers are portable and determine whether or not to check with IR at the police station	Answers only related to accuracy	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>28</b> <b>(b)(iv)</b>	Advantage It could check if you are below the legal limit / safe to drive <b>(1)</b>  Disadvantage It may not be sensitive enough to give an accurate reading / may give a value that does not closely match police value  OR  It encourages people to drink and drive <b>(1)</b>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
29(a)(i)	<p> <math>\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{NO}_2^+ + \text{H}_2\text{O} + \text{HSO}_4^-</math>  OR  <math>\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-</math>  <math>\text{H}_2\text{NO}_3^+ \rightarrow \text{NO}_2^+ + \text{H}_2\text{O}</math>  Both needed  OR  <math>2\text{H}_2\text{SO}_4 + \text{HNO}_3 \longrightarrow \text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4^-</math>  (1)  Ignore state symbols even if wrong     arrow showing attack on the nitronium ion with arrow going to N atom, or into the C - N gap (1)  Arrow must start at or inside ring  Ignore position of + charge  structure of the intermediate showing reasonable delocalisation (over at least 3 carbon atoms) (1)  arrow from the bond showing the loss of H<sup>+</sup> from the intermediate. Removal by hydrogen sulphate ion preferable but not essential (1)  Kekulé structures score full marks  If the electrophile is incorrect then the intermediate structure mark is lost </p>	<p>Delocalisation mustn't go over C where NO<sub>2</sub><sup>+</sup> is attached</p>	4

Question Number	Acceptable Answers	Reject	Mark
<b>29(a)(ii)</b> <b>QWC</b>	<p><b>First mark:</b> (lone pair of) electrons on the oxygen atom or on the OH group is delocalised / incorporated into the ring (1)</p> <p>OR</p> <p>the OH group is electron donating (1)</p> <p><b>Second mark:</b> so the ring in phenol is more negative / has increased electron density / <b>ring</b> is more nucleophilic / hence more susceptible to electrophilic attack (1)</p> <p>OR</p> <p>the OH group activates the ring (1)</p> <p>Second mark stand alone</p>	<p>Reject hydroxide for first mark only</p> <p>Nucleophilic attack on the ring</p> <p>'Makes it more reactive' on its own</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>(a)(iii)</b>	<p>tin (1) and <b>concentrated</b> hydrochloric acid (1)</p> <p>Formulae acceptable.</p> <p>If NaOH is added after HCl then ignore; if implication that HCl and NaOH are added together then second mark is lost</p> <p>OR</p> <p>iron (1) and <b>concentrated</b> hydrochloric acid (1) <b>2<sup>nd</sup> mark conditional on a metal</b></p> <p>OR</p> <p>hydrogen (1) and platinum / palladium catalyst (1)</p>	<p>lithium aluminium hydride sodium borohydride</p> <p>Nickel Raney Nickel</p>	<b>2</b>

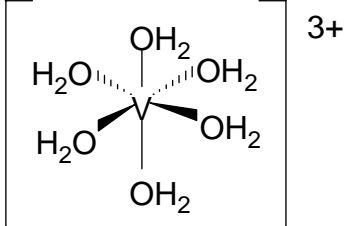


Question Number	Acceptable Answers	Reject	Mark
29(a)(iv)	ethanoyl chloride OR acetyl chloride OR $\text{CH}_3\text{COCl}$ OR equivalent displayed formula  OR  ethanoic anhydride OR acetic anhydride OR $(\text{CH}_3\text{CO})_2\text{O}$ OR equivalent displayed formula  Right name but wrong formula does not score  Ignore minor spelling errors if the formula is correct		1

Question Number	Acceptable Answers	Reject	Mark
(b) QWC	<b>First mark:</b> steam is passed into the mixture  OR  water is added and mixture boiled or distilled or heated (1)   <b>Second mark:</b> and the 2-nitrophenol / product vapour distilled off <b>with the water</b> (and condensed) (1)  <b>Advantage:</b> The 2-nitrophenol / product distils at a lower temperature / prevents decomposition(1) Stand alone	Passed over; anything that implies external heating with a steam bath or water bath  any implication of fractional distillation  any suggestion that separation based on differing boiling temperature  water-soluble	3

Question Number	Acceptable Answers	Reject	Mark
(c)	Read the whole answer to get the sense  The (ring) hydrogen atoms are on carbon atoms which have <b>one / a</b> hydrogen on an <b>adjacent</b> carbon atom, so are doublets (1)  All the other hydrogen atoms have no adjacent hydrogen (bearing carbon) atoms, so are singlets (1)	nearby	2

Question Number	Acceptable Answers	Reject	Mark
30 (a)(i)	<p>Any TWO of:</p> <p>complex ions / complexes (1)</p> <p>coloured ions / compounds / solutions (1)</p> <p>catalytic properties (1)</p> <p>paramagnetic (1)</p> <p>Allow</p> <p>coloured complexes (2)</p> <p>coloured complex compound (1)</p> <p>If a list appears with 1 or 2 correct properties followed by properties related to the element, then (1) mark only</p> <p>Ignore 'partially filled <i>d</i>-orbitals'</p>	complex compounds	2

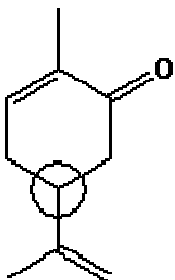
Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	 <p>ignore absence of charge</p> <p><b>clearly</b> octahedral (ignore bonds to the H in H<sub>2</sub>O) (1) but allow some latitude in the symbols used to show the 3D structure.</p> <p>Wedges do not have to be exact - if used they are enough to show 3D if the axial bonds are lines</p> <p>The word 'octahedral' does not salvage a poor drawing</p> <p>dative (covalent) / coordinate (bond) (1)</p> <p>not just shown by an arrow</p> <p>lone pair (of electrons on the oxygen) (1)</p> <p>can be shown on the diagram</p>		3

Question Number	Acceptable Answers	Reject	Mark
30(b)(i)	(+) 0.34 (V) OR (+) 0,34 V  sign not needed		1

Question Number	Acceptable Answers	Reject	Mark
(b)(ii) QWC	(simultaneous) oxidation and reduction (1)  Allow redox  of a species / substance / reactant / compound / chemical / element (1)		2

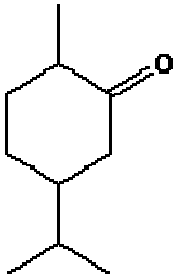
Question Number	Acceptable Answers	Reject	Mark
(b)(iii)	– 0.66(V) (1)  Allow TE from (b)(i)  reaction not feasible <b>since the potential is negative</b> (2 <sup>nd</sup> mark is for an answer consistent with sign of $E^\circ$ ) (1)		2

## Section C

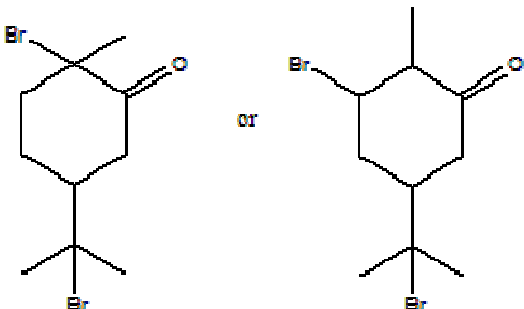
Question Number	Acceptable Answers	Reject	Mark
31 (a)		Circles that encompass two atoms	1

Question Number	Acceptable Answers	Reject	Mark
(b)	<p><b>First mark:</b> Recognition that paracetamol is not chiral / has no enantiomers / does not have optical isomers (1)</p> <p><b>Second and third marks:</b> Any two of:</p> <p>there is no racemisation so the product will not be a mixture (1)</p> <p>no need to separate (the enantiomers) (1)</p> <p>do not have to discard an unwanted enantiomer / atom economy is higher (1)</p> <p><b>OR</b></p> <p>converse arguments starting from (-)-carvone.</p>	Is not optically active	3

Question Number	Acceptable Answers	Reject	Mark
31(c)	<p>(C=C): add bromine (water) (1)</p> <p>decolourises (1)</p> <p>OR</p> <p>KMnO<sub>4</sub> (1)</p> <p>purple → brown / colourless (1)</p> <p>(C=O): add 2,4-dnp / 2,4-dinitrophenylhydrazine/ Brady's reagent (1)</p> <p>orange or yellow or orange-red or red ppt (1)</p> <p>Ignore a negative Fehling's / Tollens' test</p> <p>If a positive Fehling's / Tollens' is given in addition to 2,4 DNP then third and fourth marks are lost</p> <p>Observation dependent on test</p>	1,4-dnp	4

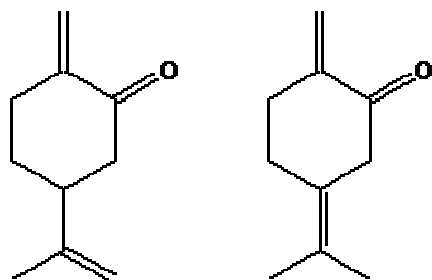
Question Number	Acceptable Answers	Reject	Mark
31(d)(i)	<p>amount of carvone = <math>(4.5 \div 150)</math> mol = 0.03 mol (1)</p> <p>amount of hydrogen = <math>(1.44 \div 24)</math> mol = 0.06 mol</p> <p>(allow 1<sup>st</sup> mark for either of the mole calculations)</p> <p>so two double bonds are reduced (1)</p> <p>OR</p> <p>2 moles H<sub>2</sub> : (1 mol carvone)</p> <p>OR</p> <p>4 mole H : (1 mol carvone)</p> <p>If hydrogen is used it must be clear whether they are atoms or molecules</p> <p>This mark can be salvaged if the structure is correct and both double bonds are reduced</p> <div style="text-align: center;">  <p>(1) stand alone</p> </div> <p>Accept displayed formula if completely correct</p>	<p>Any structure that shows reduction of the C=O bond</p>	3

Question Number	Acceptable Answers	Reject	Mark
31 (d)(ii)	<p>(a ketone/C=O) absorption / peak / trough / within the range 1680 - 1700 (<math>\text{cm}^{-1}</math>) (1)</p> <p>Ignore units</p> <p>will be seen in carvone but not in limonene / the reduction product (1)</p> <p>omission of the value for the absorption loses first mark only</p>	1720 - 1740 $\text{cm}^{-1}$	2

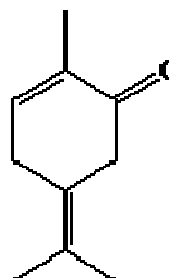
Question Number	Acceptable Answers	Reject	Mark
(e)(i)	 <p>for both double bonds having HBr added (1)</p> <p>ignore added hydrogens</p> <p>for correct orientation in <b>exocyclic</b> double bond (1) stand alone</p>	Any structure retaining C=C bonds	2

Question Number	Acceptable Answers	Reject	Mark
(e)(ii)	<p>HBr can be eliminated using a hydrogen from the carbon on either side of the bromine (1)</p> <p>which would then give a double bond in a different position from that in carvone (1)</p> <p>this second mark can be answered using a skeletal / structural formula (below)</p>	Reference to substitution	2

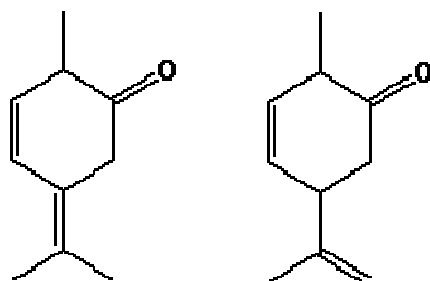
**From the left-hand structure above:**



**From either of the structures above:**



**From the right-hand structure above:**





Question Number	Acceptable Answers	Reject	Mark
31(f)(i) QWC	<p><b>Using an S<sub>N</sub>1 mechanism:</b>  selection of a chiral starting material (1)</p> <p>curly arrow from C-X bond to X (1)</p> <p>and intermediate carbocation (1)</p> <p>curly arrow from nucleophile (can come from negative charge) (1)</p> <p><b>planar intermediate</b> attacked from either side to give a racemic mixture</p> <p><b>OR</b></p> <p><b>intermediate equally</b> attacked from either side to give a racemic mixture (1)</p> <p><b>Using an S<sub>N</sub>2 mechanism:</b>  selection of a chiral starting material (1)</p> <p>curly arrow from nucleophile (can come from negative charge) (1)</p> <p>curly arrow from C-X bond to X (1)</p> <p>to give correct transition state (1)</p> <p>attack from opposite side to C-X bond gives inverted product can be shown on a diagram (1)</p> <p><b>Using nucleophilic addition to C=O:</b>  Selection of any aldehyde (other than methanal) or any asymmetric ketone (1)</p> <p>Curly arrow from nucleophile (can come from negative charge) to C of C=O and curly arrow from = to O (1)</p> <p>Intermediate (1)</p> <p>Arrow from O<sup>-</sup> of intermediate to H<sup>+</sup> (1)</p> <p><b>planar molecule</b> attacked from either side to give a racemic mixture</p> <p><b>OR</b></p> <p><b>molecule equally</b> attacked from either side to give a racemic mixture (1)</p>	<p>If H-X used then -1</p>	5

Question Number	Acceptable Answers	Reject	Mark
31(f)(ii)	heterogeneous catalysts can be filtered off OR do not appear in any liquid or gaseous products OR are easy to separate OR are stereospecific OR suited to continuous processes rather than batch processes	greater surface area	1