



## Mark Scheme (Results)

October 2022

Pearson Edexcel International Advanced  
Subsidiary Level  
In Chemistry (WCH12)  
Paper 01: Energetics, Group Chemistry,  
Halogenoalkanes and Alcohols

## Section A

Question Number	Answer	Mark
1	<p><b>The only correct answer is B (463.5)</b></p> <p><i>A is not correct because 242 has been subtracted not added</i>  <i>C is not correct because 498 has not been divided by 2</i>  <i>D is not correct because the final answer has not been divided by 2</i></p>	1

Question Number	Answer	Mark
2	<p><b>The only correct answer is A (<math>\text{Na(s)} + \frac{1}{2}\text{Cl}_2\text{(g)} \rightarrow \text{NaCl(s)}</math>)</b></p> <p><i>B is not correct because the enthalpy change of formation refers to only one mole of a compound</i>  <i>C is not correct because the Na should be solid and the Cl should be <math>\frac{1}{2}\text{Cl}_2</math></i>  <i>D is not correct because ions are not involved in the enthalpy change of formation</i></p>	1

Question Number	Answer	Mark
3	<p><b>The only correct answer is D (<math>-193 \text{ kJ mol}^{-1}</math>)</b></p> <p><i>A is not correct because <math>4 \times H_2</math> has been used, not 2 and the sign is incorrect</i>  <i>B is not correct because <math>4 \times H_2</math> has been used, not 2</i>  <i>C is not correct because the sign is incorrect</i></p>	1

Question Number	Answer	Mark
4	<p><b>The only correct answer is C (0.72 g)</b></p> <p><i>A is not correct because a 2:1 ratio has been used, not 1:2</i>  <i>B is not correct because a 1:1 ratio has been used, not 1:2</i>  <i>D is not correct because a 1:3 ratio has been used, not 1:2</i></p>	1

Question Number	Answer	Mark
5	<p><b>The only correct answer is C (solubility of the sulfates)</b></p> <p><i>A is not correct because the reactivity of the elements increases down the group</i>  <i>B is not correct because the solubility of the hydroxides increases down the group</i>  <i>D is not correct because the thermal stability of the carbonates increases down the group</i></p>	1


Question Number	Answer	Mark
6	<p><b>The only correct answer is C (4)</b></p> <p><i>A is not correct because there are 4 isomers</i>  <i>B is not correct because there are 4 isomers</i>  <i>D is not correct because there are 4 isomers</i></p>	1

Question Number	Answer	Mark
7	<p><b>The only correct answer is D</b> (nucleophilic substitution)</p> <p><i>A is not correct because the <math>\text{CN}^-</math> ion is a nucleophile and the reaction is a substitution</i>  <i>B is not correct because the reaction is a substitution</i>  <i>C is not correct because the <math>\text{CN}^-</math> ion is a nucleophile</i></p>	1

Question Number	Answer	Mark
8	<p><b>The only correct answer is D</b> (energy emitted, from excited state to ground state)</p> <p><i>A is not correct because the flame colour is not caused by the absorption of energy</i>  <i>B is not correct because electrons do not emit energy on promotion</i>  <i>C is not correct because electrons do not absorb energy on returning to the ground state</i></p>	1

Question Number	Answer	Mark
9	<p><b>The only correct answer is A</b> (hydrogen iodide has stronger London forces than hydrogen bromide)</p> <p><i>B is not correct because hydrogen iodide has a smaller permanent dipole than hydrogen bromide</i>  <i>C is not correct because neither HBr or HI can form hydrogen bonds</i>  <i>D is not correct because the H–I bond is weaker than the H–Br bond</i></p>	1

Question Number	Answer	Mark
10	<p>The only correct answer is B (<math>\text{NaNO}_3</math>)</p> <p><i>A is not correct because both oxygen and nitrogen dioxide would be produced</i>  <i>C is not correct because both oxygen and nitrogen dioxide would be produced</i>  <i>D is not correct because both oxygen and nitrogen dioxide would be produced</i></p>	1

Question Number	Answer	Mark
11	<p>The only correct answer is B (  )</p> <p><i>A is not correct because propan-2-ol has a lower boiling temperature as the alcohol is branched</i>  <i>C is not correct because butane has a lower boiling temperature as it does not form hydrogen bonds</i>  <i>D is not correct because 2-methylpropane has a lower boiling temperature as it does not form hydrogen bonds</i></p>	1

Question Number	Answer	Mark
12	<p>The only correct answer is A (<math>\text{HCl}</math>)</p> <p><i>B is not correct because hydrogen bonds form between molecules of <math>\text{H}_2\text{O}</math></i>  <i>C is not correct because hydrogen bonds form between molecules of <math>\text{HF}</math></i>  <i>D is not correct because hydrogen bonds form between molecules of <math>\text{NH}_3</math></i></p>	1

Question Number	Answer	Mark
13	<p><b>The only correct answer is C (+5)</b></p> <p><i>A is not correct because the oxidation number is +5 in <math>\text{BrO}_3^-</math></i>  <i>B is not correct because the oxidation number is +5 in <math>\text{BrO}_3^-</math></i>  <i>D is not correct because the oxidation number is +5 in <math>\text{BrO}_3^-</math></i></p>	<b>1</b>

Question Number	Answer	Mark
14	<p><b>The only correct answer is D</b> (<math>\text{Zn(s)} + \text{CuSO}_4\text{(aq)} \rightarrow \text{ZnSO}_4\text{(aq)} + \text{Cu(s)}</math>)</p> <p><i>A is not correct because Cl has undergone disproportionation</i>  <i>B is not correct because O has undergone disproportionation</i>  <i>C is not correct because Cl has undergone disproportionation</i></p>	1

Question Number	Answer	Mark
15	<p><b>The only correct answer is D</b> (reactivity of the elements increases)</p> <p><i>A is not correct because atomic radius increases down the group</i>  <i>B is not correct because the boiling temperature increases down the group</i>  <i>C is not correct because electronegativity decreases down the group</i></p>	1

Question Number	Answer	Mark
16	<p><b>The only correct answer is A</b> (0.75)</p> <p><i>B is not correct because this is the reciprocal of the correct answer</i>  <i>C is not correct because this is the total volume at 40 seconds divided by 40</i>  <i>D is not correct because this is the initial rate</i></p>	1

Question Number	Answer	Mark
17(a)	<p><b>The only correct answer is C</b> (the area under the curve to the right of the activation energy, <math>E_a</math> represents the number of particles with enough energy to react)</p> <p><i>A is not correct because this is the mode energy of the particles</i>  <i>B is not correct because the activation energy is the minimum energy required for a reaction to take place</i>  <i>D is not correct because a catalyst would move the activation energy to the left</i></p>	1

Question Number	Answer	Mark
17(b)	<p><b>The only correct answer is D</b> (shifts to the left, higher)</p> <p><i>A is not correct because the curve would shift to the left and the peak would be higher</i>  <i>B is not correct because the curve would shift to the left</i>  <i>C is not correct because the peak would be higher</i></p>	1

Question Number	Answer	Mark
18	<p><b>The only correct answer is C</b> (arrow 3)</p> <p><i>A is not correct because the arrow 1 is correctly used</i>  <i>B is not correct because the arrow 2 is correctly used</i>  <i>D is not correct because the arrow 4 is correctly used</i></p>	1

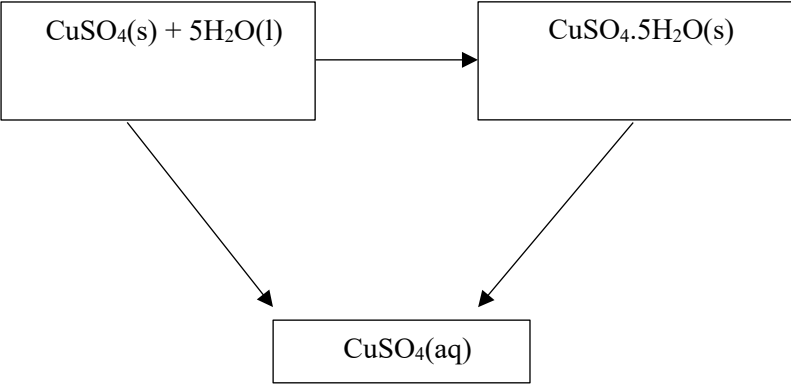


Question Number	Answer	Mark
19	<p><b>The only correct answer is B</b> (yellow to orange and pink to colourless)</p> <p><i>A is not correct because the phenolphthalein colour change is reversed and the methyl orange colour change is for acid to neutral</i></p> <p><i>C is not correct because the methyl orange colour change is for acid to neutral</i></p> <p><i>D is not correct because the phenolphthalein colour change is reversed</i></p>	<b>1</b>

**Total for Section A = 20 Marks**

## Section B

Question Number	Answer	Additional Guidance	Mark
20(a)	<ul style="list-style-type: none"> <li>M1 moles of <math>\text{CuSO}_4 \cdot 5\text{H}_2\text{O}</math> (1)</li> <li>M2 energy change (1)</li> <li>M3 enthalpy change per mole (1)</li> <li>M4 correct sign <b>and</b> units <b>and</b> 2 or 3 SF (1)</li> </ul> <p>Note M4 is not a stand-alone mark it depends on a sensible calculation by dividing joules by a number of moles.</p>	<p><u>Example of calculation:</u></p> <p><math>10.68 \div 249.6 = 0.042788 / 89 \div 2080</math></p> <p><math>2.5 \times 55 \times 3.70 = 508.75 \text{ (J)} = 0.50875 \text{ (kJ)}</math></p> <p><math>508.75 \div 0.042788 = 11890 \text{ (J mol}^{-1}\text{)}</math> Or <math>0.50875 \div 0.042788 = 11.890 \text{ (kJ mol}^{-1}\text{)}</math></p> <p><math>(+)11900 \text{ J mol}^{-1} / (+)11.9 \text{ kJ mol}^{-1} / (+)12000 \text{ J mol}^{-1} / (+)12 \text{ kJ mol}^{-1}</math></p> <p>TE throughout</p> <p>Correct answer with sign and units and 2-3 SF score (4)</p>	4

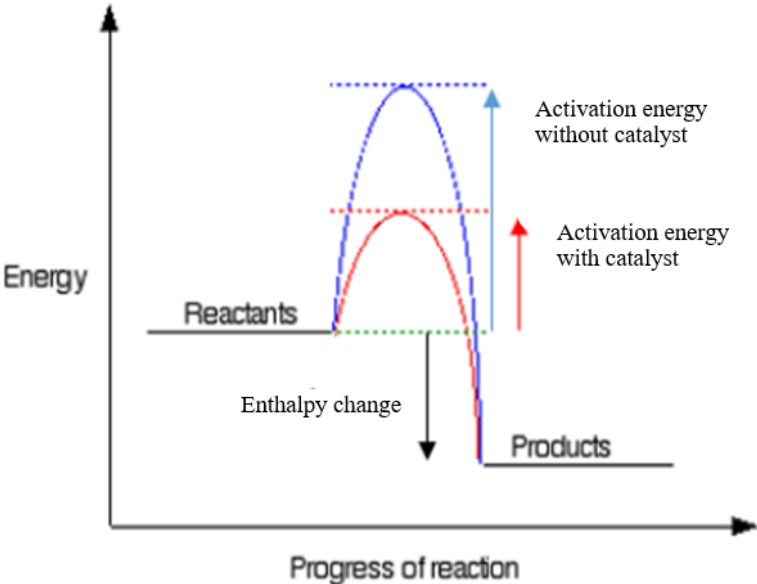
Question Number	Answer	Additional Guidance	Mark
20(b)(i)	<p>A diagram which shows</p> <ul style="list-style-type: none"> <li>• both arrows pointing down</li> <li>• correct product in box</li> </ul>	<p>Example of diagram</p>  <pre> graph TD     A["CuSO4(s) + 5H2O(l)"] --&gt; B["CuSO4.5H2O(s)"]     A --&gt; C["CuSO4(aq)"]     B --&gt; C   </pre> <p>Ignore any extra water in the box e.g. + 5H<sub>2</sub>O</p> <p>Ignore any numbers on the arrows</p> <p>Allow ions separated Cu<sup>2+</sup> (aq) and SO<sub>4</sub><sup>2-</sup> (aq)</p> <p>Allow CuSO<sub>4</sub> + (aq)</p>	2

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	<ul style="list-style-type: none"> <li>correct use of data</li> <li>correct sign and answer</li> </ul> <p>Note the only TE is using their value from (a).</p>	<p><u>Example of calculation:</u></p> <p>(+) <math>-67.4 \text{ (kJ mol}^{-1}\text{)}</math> (-) <math>+11.9 \text{ (kJ mol}^{-1}\text{)}</math></p> <p><math>-79.3 / -79 \text{ (kJ mol}^{-1}\text{)}</math> Ignore units unless wrong but not award mixed units</p> <p>Allow <math>-79.16 \text{ (kJ mol}^{-1}\text{)}</math> for rounding moles to 0.43 Allow TE on value from (a).</p> <p>No TE on incorrect cycle Ignore SF</p>	2

**Total for Question 20 = 8 Marks**

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• <b>both</b> have London forces (only) (1)</li> <li>• S molecules have more electrons (1) / S is a larger molecule (than oxygen) / S electrons are more easily polarised</li> </ul> <p>Independent marks</p>	<p>Accept dispersion forces Accept instantaneous dipole-induced dipoles Allow van der Waals' forces</p> <p>Note any mention of other intermolecular forces being present e.g. dipole-dipole negates M1</p> <p>Allow S<sub>8</sub>, rather than O<sub>2</sub> Allow just S has more electrons Allow just S is larger Allow reverse argument Ignore electron density Do not award a S atom has more electrons than an oxygen molecule</p>	

Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	<p>An answer that makes reference to the following points:</p> <p>Increasing temperature</p> <ul style="list-style-type: none"> <li>equilibrium shifts to the LHS/backwards (1)</li> <li>in the endothermic direction (in order to reduce the temperature) (1)</li> </ul> <p>Increasing pressure</p> <ul style="list-style-type: none"> <li>equilibrium shifts to the RHS/forward (1)</li> <li>to the side with fewer (gaseous) molecules/moles (in order to reduce the pressure) (1)</li> </ul> <p>Independent marks</p>	<p>Ignore any reference to yield</p> <p>Allow reaction is exothermic Allow favours endothermic direction</p> <p>Allow favours RHS/forward direction</p> <p>Allow 3 moles (of gas ) on the LHS (forms) 2 moles(of gas) on the RHS. If numbers of moles are quoted they must be correct. Allow reverse argument Ignore any reference to rate</p>	4

Question Number	Answer	Additional Guidance	Mark
21(a)(iii)	<ul style="list-style-type: none"> <li>reactants/(2)SO<sub>2</sub> + O<sub>2</sub> higher than products/(2)SO<sub>3</sub> (1)</li> <li>non-catalysed activation energy correctly labelled and arrow going up (1)</li> <li>catalysed activation energy correctly labelled and arrow going up (1)</li> <li>enthalpy change labelled and arrow going down (1)</li> </ul> <p>If just one curve is drawn max (3)</p> <p>MB distribution scores (0)</p> <p>If endothermic reaction TE available for M2, M3 and M4</p> <p>Double-headed arrows or no arrow heads penalise once</p>	 <p>Allow energy for enthalpy  Allow <math>E_a</math> and <math>E_{cat}</math>  Allow intermediates in the activation energy curves  Ignore sign and units of energy even if incorrect</p>	4

Question Number	Answer	Additional Guidance	Mark
21(a)(iv)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• (operates at) a lower temperature (1)</li> <li>• less energy required (for the reaction to proceed at an acceptable rate) or less burning of fossil fuels / less greenhouse gas evolved / less CO<sub>2</sub> evolved (1)</li> </ul>	<p>Allow lower temperature</p> <p>Allow less energy costs Ignore just cheaper Ignore less time/faster rate</p> <p>Allow less pollution</p>	2



Question Number	Answer	Additional Guidance	Mark																				
*21(b)	<p>This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5-4</td><td>3</td></tr><tr><td>3-2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table> <p>The following table shows how the marks should be awarded for structure and lines of reasoning</p> <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	<p>Guidance on how the mark scheme should be applied.</p> <p>The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).</p> <p>If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</p> <p>In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning and 0, 1 or 2 indicative points would score zero marks for reasoning.</p> <p>If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).</p> <p>Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning</p>	6
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
3-2	2																						
1	1																						
0	0																						
	Number of marks awarded for structure of answer and sustained lines of reasoning																						
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																						
Answer is partially structured with some linkages and lines of reasoning	1																						
Answer has no linkages between points and is unstructured	0																						

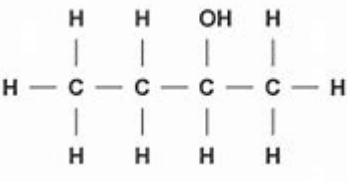
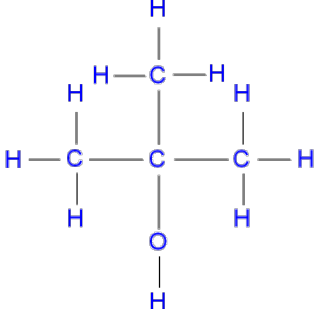
	<p><b>Indicative content</b></p> <p><u>Potassium chloride</u></p> <p>IP1 (misty/steamy fumes of) HCl/hydrogen chloride</p> <p><u>Potassium iodide</u></p> <p>IP2 purple vapour/black solid <b>and</b> I<sub>2</sub>/iodine</p> <p>IP3 bad eggs <b>and</b> H<sub>2</sub>S/ hydrogen sulfide OR yellow solid <b>and</b> S/ sulfur OR Choking gas <b>and</b> SO<sub>2</sub>/sulfur dioxide</p> <p>IP4 KCl is <b>not</b> a redox reaction and KI is a redox reaction / KCl cannot reduce sulfuric acid but KI can</p> <p>IP5 iodide stronger reducing agent than chloride</p>	<p>Note observation is not required for IP This can be seen in an equation</p> <p>Ignore any reference to hydrogen iodide/HI/misty fumes</p> <p>The two parts of this answer may often be seen in different places.</p> <p>Allow hydrogen iodide or potassium iodide is a stronger reducing agent than hydrogen chloride or potassium chloride. Allow reducing ability (of the halides) increases down the group Or reverse argument</p> <p>Do not award iodine/I is a stronger reducing agent than chlorine/Cl</p>	
--	---	---	--

<p>IP6 (because) S is reduced from +6 to <math>-2</math> in <math>\text{H}_2\text{S}</math>  OR  S is reduced from +6 to 0 in S  OR  S is reduced from +6 to +4 in <math>\text{SO}_2</math>  OR  Any balanced equation making <math>\text{H}_2\text{S}</math>, <math>\text{SO}_2</math>, or S showing electrons  eg  <math display="block">8\text{H}^+ + \text{H}_2\text{SO}_4 + 8\text{e}^- \longrightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O}</math> <math display="block">2\text{H}^+ + \text{H}_2\text{SO}_4 + 2\text{e}^- \longrightarrow \text{SO}_2 + 2\text{H}_2\text{O}</math> <math display="block">6\text{H}^+ + \text{H}_2\text{SO}_4 + 6\text{e}^- \longrightarrow \text{S} + 4\text{H}_2\text{O}</math></p>	<p>Allow just correct stated product and oxidation number eg <math>-2</math> in <math>\text{H}_2\text{S}</math> or 0 in S or +4 in <math>\text{SO}_2</math></p> <p>Ignore <math>\text{I}_2</math> oxidation number = 0</p>
---	--

Question Number	Answer	Additional Guidance	Mark
21(c)	<ul style="list-style-type: none"> <li>number of moles of sulfuric acid in 40.5 cm<sup>3</sup> (1)</li> <li>concentration of the concentrated sulfuric acid (1)</li> </ul>	<p><u>Example of calculation</u></p> <p><math>1.5 \times 500 \div 1000 = 0.75 \text{ (mol)}</math></p> <p><math>0.75 \times 1000 \div 40.5 = 18.519 \text{ (mol dm}^{-3}\text{)}</math></p> <p>Allow TE on incorrect moles</p> <p>Units not required but if given they must be correct</p> <p>Correct answer with or without working scores (2)</p> <p>Ignore SF except 1 SF</p>	2

**Total for Question 21 = 20 marks**

Question Number	Answer	Additional Guidance	Mark
22(a)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>contains the OH group/OH is the alcohol group (1)</li> <li>primary means the C bonded to the OH (group) is attached to 1 (or 0) alkyl group / carbon atom/ R group (1)</li> </ul>	<p>Accept a hydrocarbon in which one H atom has been replaced by an OH group  Allow contains O-H bond  Allow contains a C-OH bond  Ignore hydroxyl  Do not award hydroxide/ OH<sup>-</sup></p> <p>Allow the OH group is attached to a carbon atom bonded to 2 (or 3) H atoms  Do not award the OH is attached to a single R/alkyl/carbon group</p>	2

Question Number	Answer				Additional Guidance	Mark
22(b)	Name	butan-1-ol		(2-)methylpropan-2-ol	(2) One mark for each name	5
	Displayed formula				(2) One mark for each correct displayed formula	
	Nature of alcohol	primary	secondary		(1) One mark for both alcohol types  Allow CH <sub>3</sub> and OH undisplayed Penalise missing Hs only once.	

Question Number	Answer	Additional Guidance	Mark
22(c)(i)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>potassium dichromate(VI) / <math>K_2Cr_2O_7</math> (1)</li> <li>sulfuric acid / <math>H_2SO_4</math> (1)</li> </ul> <p>Note M2 depends on M1 or a near miss such as potassium permanganate or potassium dichromate with the wrong oxidation number</p>	<p>Allow sodium dichromate(VI) / <math>Na_2Cr_2O_7</math> If oxidation state is given it must be correct Do not award potassium manganate(VII) / potassium permanganate</p> <p>Do not award hydrochloric acid Ignore just 'acidified' Ignore concentration of sulfuric acid Ignore heat</p> <p>If no other mark is scored acidified dichromate / <math>H^+</math> and <math>Cr_2O_7^{2-}</math> score (1)</p>	2

Question Number	Answer	Additional Guidance	Mark
22(c)(ii)	<ul style="list-style-type: none"> <li><math>(CH_3)_2CHCH_2OH + [O] \rightarrow (CH_3)_2CHCHO + H_2O</math></li> </ul>	<p>Allow <math>C_4H_{10}O + [O] \rightarrow C_4H_8O + H_2O</math></p> <p>The [O] may be above the arrow</p> <p>Allow displayed/molecular/skeletal</p>	1

Question Number	Answer	Additional Guidance	Mark
22(c)(iii)	<p>An answer that makes reference to two of the following points:</p> <ul style="list-style-type: none"> <li>• (resulting mixture) would give a peak due to O–H bond in alcohols at 3750-3200 (<math>\text{cm}^{-1}</math>)</li> <li>• would give a peak due to C=O bond in aldehydes at 1740-1720 (<math>\text{cm}^{-1}</math>) or would give a peak due to C–H bond in CHO at 2900-2820 and/ or 2775-2700 (<math>\text{cm}^{-1}</math>)</li> </ul>	<p>Ignore any reference to the size/width of the peaks due to stretching etc</p> <p>Allow (resulting mixture) would give a peak due to OH (in alcohols) at 3750-3200 (<math>\text{cm}^{-1}</math>) Do not award -OH</p> <p>Do not award 1720-1700 (<math>\text{cm}^{-1}</math>) for C=O in ketones</p> <p>Allow any range within the range. Do not award single numbers but penalise once only</p> <p>If no other marks have been scored a correct wave number range for both the O-H and C=O score (1) 3750-3200 (<math>\text{cm}^{-1}</math>) 1740-1720 (<math>\text{cm}^{-1}</math>)</p>	

**(Total for Question 22 = 12 Marks)**



### Section C

Question Number	Answer	Additional Guidance	Mark
23(a)(i)	$\text{TiO}_2 + 2\text{Cl}_2 + 2\text{C} \rightarrow \text{TiCl}_4 + 2\text{CO}$	Ignore state symbols even if incorrect Allow multiples	1

Question Number	Answer	Additional Guidance	Mark
23(a)(ii)	<ul style="list-style-type: none"> <li>Ti is reduced <b>and</b> from +4 to 0</li> <li>Mg is oxidised <b>and</b> from 0 to +2</li> </ul>	<p>(1) Four correct oxidation numbers with no or incorrect mention of reduced or oxidised scores (1)</p> <p>(1) Ti is reduced as it gains electrons and Mg is oxidised as it loses electrons with no or incorrect oxidation numbers scores (1)</p>	2

Question Number	Answer	Additional Guidance	Mark
23(b)	<ul style="list-style-type: none"> <li>hydrolysis</li> <li>titanium(IV) oxide/<math>\text{TiO}_2</math></li> </ul>	<p>(1) Do not award hydration</p> <p>(1) Ignore hydrogen chloride/HCl Allow titanium(IV)hydroxide/<math>\text{Ti}(\text{OH})_4</math></p> <p>If both name and formula/oxidation number are given they must all be correct</p>	2

Question Number	Answer	Additional Guidance	Mark
23(c)	<div data-bbox="371 296 831 571" data-label="Chemical-Block"> </div> <ul style="list-style-type: none"> <li>• correct repeating unit</li> <li>• two repeating units and extension</li> </ul> <p>Note M2 depends on M1 or near miss eg missing a H</p>	<p>(1) Allow adjacent pairs of methyl groups</p> <p>(1) Ignore square brackets and subscript n/2</p> <p>Ignore connectivity of CH<sub>3</sub></p>	2

Question Number	Answer	Additional Guidance	Mark
23(d)(i)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>reagent: potassium hydroxide / KOH (1)</li> <li>conditions: aqueous/water (1)</li> </ul> <p>M2 dependent on M1 or near miss e.g. OH<sup>-</sup> will not score M1 but will allow access to M2.</p>	<p>Allow sodium hydroxide / NaOH</p> <p>Ignore any reference to concentration or heat</p> <p>Allow dilute</p>	2

Question Number	Answer	Additional Guidance	Mark
23(d)(ii)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>reagent: (concentrated) phosphoric(V) acid / H<sub>3</sub>PO<sub>4</sub> (1)</li> <li>reaction type: elimination/dehydration (1)</li> </ul> <p>Independent marks</p>	<p>Allow (concentrated) sulfuric acid</p> <p>Ignore heat</p> <p>Do not award H<sub>3</sub>PO<sub>3</sub></p> <p>Allow passing vapour over porous pot / alumina or any surface catalyst <b>and</b> heat</p>	2

Question Number	Answer	Additional Guidance	Mark
23(d)(iii)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>reagent: phosphorus(V) chloride/ phosphorus pentachloride/PCl<sub>5</sub> (1)</li> <li>equation: <math>\text{C}_4\text{H}_9\text{OH} + \text{PCl}_5 \rightarrow \text{C}_4\text{H}_9\text{Cl} + \text{HCl} + \text{POCl}_3</math> (1)</li> </ul>	<p>Allow thionyl chloride / SOCl<sub>2</sub>  Allow phosphorus (III) chloride / phosphorus trichloride / PCl<sub>3</sub>    Allow  <math>\text{C}_4\text{H}_9\text{OH} + \text{SOCl}_2 \rightarrow \text{C}_4\text{H}_9\text{Cl} + \text{HCl} + \text{SO}_2</math>  <math>3\text{C}_4\text{H}_9\text{OH} + \text{PCl}_3 \rightarrow 3\text{C}_4\text{H}_9\text{Cl} + \text{H}_3\text{PO}_3</math>    Allow skeletal, structural, displayed or molecular formulae</p>	2

Question Number	Answer	Additional Guidance	Mark
23(d)(iv)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>conditions: alcoholic (1)</li> <li>role of the hydroxide ions: base (1)</li> </ul> <p>Note answers may be given on either line</p>	<p>Allow ethanol/ethanolic  Ignore heat and concentration    Allow proton acceptor/reacts with H<sup>+</sup></p>	2

Question Number	Answer	Additional Guidance	Mark
23(e)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• moles of carbon dioxide (1)</li> <li>• conversion of cm<sup>3</sup> to m<sup>3</sup> (1)</li> <li>• conversion of °C to K (1)</li> <li>• rearrangement of the ideal gas equation (1)</li> <li>• calculation of pressure and correct units given (1)</li> </ul>	<p><u>Examples of calculation</u></p> <p>16 ÷ 44 = 0.36364 (mol)/ 4÷11(mol)</p> <p>20 ÷ 1000000 = 2 × 10<sup>-5</sup> / 0.00002 (m<sup>3</sup>)</p> <p>273 + 25 = 298 (K)</p> <p><math>p = \frac{nRT}{V}</math></p> <p><math>\frac{0.3636 \times 8.31 \times 298}{2 \times 10^{-5}} = 45025000 \text{ Pa} / 45025 \text{ kPa}</math>  4.5 x 10<sup>7</sup> Pa / 45MPa</p> <p>Ignore SF except 1</p> <p>Allow TE for answers to M1, M2 and M3  But no TE on wrong rearrangement of gas equation</p> <p>Correct answer, including units with or without working scores (5)</p>	5

**Total for Question 23 = 20 Marks**  
**Total for Section C = 20 Marks**  
**TOTAL FOR PAPER = 80 MARKS**