

## Unit 2 - Mark scheme

| Question number | Answer    | Mark |
|-----------------|-----------|------|
| 1               | D pentane | 1    |

| Question number | Answer    | Mark |
|-----------------|-----------|------|
| 2               | B Y X Z W | 1    |

| Question number | Answer                                        | Mark |
|-----------------|-----------------------------------------------|------|
| 3               | A all Group 1 hydroxides are soluble in water | 1    |

| Question number | Answer                     | Mark |
|-----------------|----------------------------|------|
| 4               | C 2-chloro-2-methylpropane | 1    |

| Question number | Answer                                | Mark |
|-----------------|---------------------------------------|------|
| 5               | D <i>E</i> -1-bromo-2-methylbut-1-ene | 1    |

| Question number | Answer                      | Mark |
|-----------------|-----------------------------|------|
| 6               | D nucleophilic substitution | 1    |

| Question number | Answer                                                                                                                                                                                                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7               | <div style="text-align: center;"> <math display="block">  \begin{array}{c}  \text{CH}_3 \\    \\  \text{CH}_3 - \text{C} - \text{CH}_2 - \text{O} - \text{H} \\    \\  \text{CH}_3  \end{array}  </math> </div> <p>D</p> | 1    |

| Question number | Answer                                   | Mark |
|-----------------|------------------------------------------|------|
| 8               | C The solubility of hydroxides increases | 1    |

| Question number | Answer                   | Mark |
|-----------------|--------------------------|------|
| 9               | B $\text{NH}_4\text{Cl}$ | 1    |

| Question number | Answer                                                                             | Mark |
|-----------------|------------------------------------------------------------------------------------|------|
| 10              | D dilute nitric acid followed by silver nitrate solution gives a white precipitate | 1    |

| Question number | Answer            | Mark |
|-----------------|-------------------|------|
| 11              | B lithium sulfate | 1    |

| Question number | Answer                                                                        | Mark |
|-----------------|-------------------------------------------------------------------------------|------|
| 12              | C emission of visible light energy as electrons return to lower energy levels | 1    |

| Question number | Answer      | Mark |
|-----------------|-------------|------|
| 13              | B -1 and +5 | 1    |

| Question number | Answer                                              | Mark |
|-----------------|-----------------------------------------------------|------|
| 14              | C bromine, hydrogen bromide and sulfur dioxide only | 1    |

| Question number | Answer   | Mark |
|-----------------|----------|------|
| 15(a)           | A 2.5 °C | 1    |

| Question number | Answer  | Mark |
|-----------------|---------|------|
| 15(b)           | C redox | 1    |

| Question number | Answer                                       | Mark |
|-----------------|----------------------------------------------|------|
| 16              | A an increase in the volume of acid solution | 1    |

| Question number | Answer                                           | Mark |
|-----------------|--------------------------------------------------|------|
| 17(a)           | A peak position shifted left, peak height higher | 1    |

| Question number | Answer                               | Mark |
|-----------------|--------------------------------------|------|
| 17(b)           | B area A decreases, area B increases | 1    |

| Question number | Answer                                                | Mark |
|-----------------|-------------------------------------------------------|------|
| 18              | C the forward and reverse reactions have both stopped | 1    |

| Question number | Answer                                                                                              | Additional guidance                                                                                                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 19(a)           | <ul style="list-style-type: none"> <li>KBr/potassium bromide and (50%) sulfuric acid (1)</li> </ul> | Both needed for M1<br>Ignore acid concentration<br>Allow HBr (dry)<br>PBr <sub>3</sub> /Phosphorus(III) bromide<br>PBr <sub>5</sub> /Phosphorus(V) bromide | 2    |
|                 | <ul style="list-style-type: none"> <li>(heat under) reflux (1)</li> </ul>                           | Do not allow just heat<br>M2 conditional on correct or near correct M1                                                                                     |      |

| Question number | Answer                                                                                        | Additional guidance | Mark |
|-----------------|-----------------------------------------------------------------------------------------------|---------------------|------|
| 19(b)           | <ul style="list-style-type: none"> <li>C-Br dipole reversed (1)</li> </ul>                    | Allow in any order  | 3    |
|                 | <ul style="list-style-type: none"> <li>OH<sup>-</sup> to C arrow reversed (1)</li> </ul>      |                     |      |
|                 | <ul style="list-style-type: none"> <li>lone pair missing (from OH<sup>-</sup>) (1)</li> </ul> |                     |      |

| Question number | Answer                                                                                                | Additional guidance                                                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------|
| 19(c)           | <ul style="list-style-type: none"> <li>KOH/potassium hydroxide (1)</li> </ul>                         | Allow NaOH/sodium hydroxide<br>Ignore OH <sup>-</sup> / alkali<br>M2 dependent on M1 | 2    |
|                 | <ul style="list-style-type: none"> <li>ethanol(ic)/alcohol(ic) and heat (under reflux) (1)</li> </ul> |                                                                                      |      |

| Question number | Answer                                                                               | Additional guidance                                   | Mark |
|-----------------|--------------------------------------------------------------------------------------|-------------------------------------------------------|------|
| 20(a)           |                                                                                      | Example of calculation:                               | 2    |
|                 | <ul style="list-style-type: none"> <li>calculation of number of moles (1)</li> </ul> | 0.0500 cm <sup>3</sup> (× 1000 ÷ 1000) = 0.0500 (mol) |      |
|                 | <ul style="list-style-type: none"> <li>evaluation to 2/3 SF (1)</li> </ul>           | (0.0500 × 90.0) = 4.50 (g)                            |      |

| Question number | Answer                                                                                                                                                                                                           | Additional guidance                                                                                                                                                                                                                                                                                                                                                          | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 20(b)           | <p>An answer that make reference to the following points:</p> <ul style="list-style-type: none"> <li>moles of ethanedioic acid</li> <li>moles of potassium hydroxide and mass of potassium hydroxide.</li> </ul> | <p>Example of calculation:</p> <p>(1) Moles acid = <math>400 \times 0.0500 \div 1000 = 2.00 \times 10^{-2}</math></p> <p>(1) Moles KOH = <math>2.00 \times 10^{-2} \times 2 = 4.00 \times 10^{-2}</math> mol<br/> <math>4.00 \times 10^{-2} \times 56.1 = 2.24(4)</math> g</p> <p>Correct answer with no working scores 2<br/>                     Ignore SF except 1 SF</p> | 2    |

| Question number                                                                                                             | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional guidance                                | Mark                                                  |   |   |     |   |     |   |   |   |   |   |  |                                                                        |                                                                                                                             |   |                                                                           |   |                                                            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |
|-----------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------|---|---|-----|---|-----|---|---|---|---|---|--|------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|---|---------------------------------------------------------------------------|---|------------------------------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 20(c)                                                                                                                       | <p>This question assesses a 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 and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent and 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 and sustained lines of reasoning | Answer shows a coherent and 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, an answer 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 are no linkages between points, the same five 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 and sustained lines of reasoning                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                    |                                                       |   |   |     |   |     |   |   |   |   |   |  |                                                                        |                                                                                                                             |   |                                                                           |   |                                                            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |
| Answer shows a coherent and 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                    |                                                       |   |   |     |   |     |   |   |   |   |   |  |                                                                        |                                                                                                                             |   |                                                                           |   |                                                            |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |   |

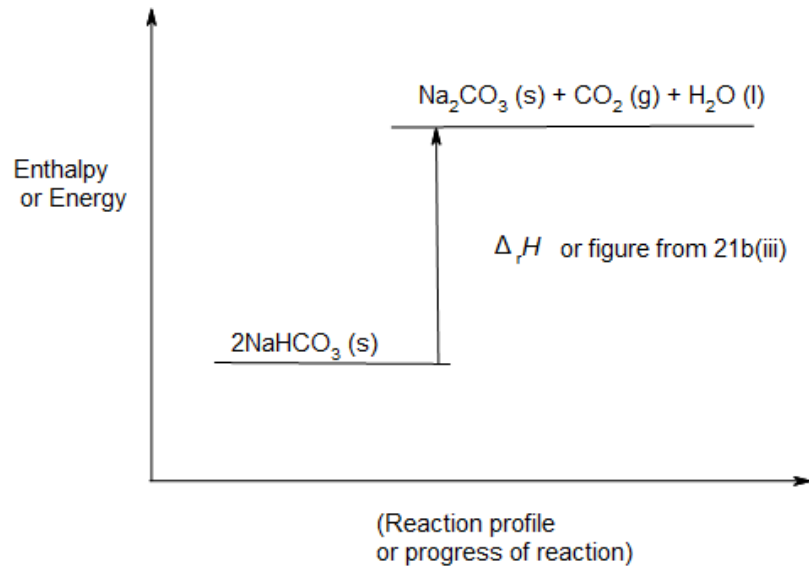
| Question number       | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Mark |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 20(c)<br><i>Cont.</i> | <p>Indicative points:</p> <ul style="list-style-type: none"> <li>• rinse glassware with appropriate solutions</li> <li>• fill the burette with potassium hydroxide solution, ensuring there are no air bubbles</li> <li>• use a pipette <b>and</b> pipette filler to transfer <math>25.0 \text{ cm}^3</math> / <math>10 \text{ cm}^3</math> of acid to a conical flask</li> <li>• (add indicator to the acid in the conical flask and) carry out a range finder/rough titration</li> <li>• add potassium hydroxide drop by drop near the end point</li> <li>• repeat titrations <b>until</b> concordant/within <math>\pm 0.2 \text{ cm}^3</math>.</li> </ul> | <p>Do not award just ‘rinse with distilled water’. Alternative IP 2 to 5 if acid (solution) used in burette:</p> <ul style="list-style-type: none"> <li>• fill the burette with (ethanedioic) acid solution, ensuring there are no air bubbles</li> <li>• use a pipette <b>and</b> pipette filler to transfer <math>25.0 \text{ cm}^3</math> of potassium hydroxide solution to a conical flask</li> <li>• (add indicator to the potassium hydroxide in the conical flask and) carry out a range finder/rough titration</li> <li>• add (ethanedioic) acid drop by drop near the end point.</li> </ul> |      |

| Question number | Answer                                                                                                                                                                                                                                                                                   | Additional guidance                                         | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------|
| 21(a)           | <ul style="list-style-type: none"> <li>• hard to measure the temperature change when you’re heating something<br/>or</li> <li>• heat losses due to high temperatures involved<br/>or</li> <li>• at <math>300^\circ\text{C}</math>/high temperatures the water will be gaseous</li> </ul> | Allow it is difficult to measure the temperature of a solid | 1    |

| Question number | Answer                                                                                                                                                                                                                                                                 | Additional guidance | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 21(b)(i)        | <p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• (the enthalpy change when) one mole of the substance (is formed)</li> <li>• from its elements in their standard states (under standard conditions).</li> </ul> |                     | 2    |

| Question number | Answer                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                                                                                                | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 21(b)(ii)       | <p>A diagram that includes:</p> <ul style="list-style-type: none"> <li>all species correct (1)</li> <li>all state symbols correct and species balanced. (1)</li> </ul> | $  \begin{array}{c}  2\text{NaHCO}_3(\text{s}) \longrightarrow \text{Na}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \\  \swarrow \quad \searrow \\  2\text{Na}(\text{s}) + \text{H}_2(\text{g}) + 2\text{C}(\text{s, graphite}) + 3\text{O}_2(\text{g})  \end{array}  $ <p>Do not penalise missing graphite</p> | 2    |

| Question number | Answer                                                                                                                                                                                 | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 21(b)(iii)      | <ul style="list-style-type: none"> <li>correct application of Hess's law (1)</li> <li>correct figures used (1)</li> <li>correct calculation (1)</li> <li>units and sign (1)</li> </ul> | <p>Example of calculation:</p> $\Delta_r H = -\Delta H_1 + \Delta H_2$ <p>or</p> $\Delta_f H (\text{Na}_2\text{CO}_3) + \Delta_f H (\text{CO}_2) + \Delta_f H (\text{H}_2\text{O}) = 2\Delta_f H (\text{NaHCO}_3) + \Delta_r H$ $-1130.7 + (-285.8) + (-393.5) = 2 \times (-950.8) + \Delta_r H$ $\Delta_r H = 91.6$ $\Delta_r H = +91.6 \text{ kJ mol}^{-1}$ <p>Correct answer with no working scores (4)<br/>TE from M1<br/>TE from incorrect M2</p> | 4    |

| Question number | Answer                                                                                                                                                                           | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 21(b)(iv)       | <ul style="list-style-type: none"> <li>products energy level above reactants <b>and</b> arrow (1)</li> <li>label on vertical arrow <b>and</b> vertical axis label (1)</li> </ul> |  <p>Enthalpy or Energy</p> <p><math>\text{Na}_2\text{CO}_3 (\text{s}) + \text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\text{l})</math></p> <p><math>\Delta_r H</math> or figure from 21b(iii)</p> <p><math>2\text{NaHCO}_3 (\text{s})</math></p> <p>(Reaction profile or progress of reaction)</p> <p>Allow reactants/products in place of chemical formulae<br/>Horizontal axis label not required<br/>Direction of arrow and endothermic/exothermic diagram must agree with sign in 21b(iii)</p> <p>Allow a correct exothermic enthalpy level diagram for an exothermic answer in 21b(iii)</p> | 2    |

| Question number | Answer                                                                                                                                             | Additional guidance                                                                                   | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------|
| 22(a)(i)        | <ul style="list-style-type: none"> <li>peak in the range <math>3750 - 3200 \text{ cm}^{-1}</math> and O-H (stretching) bond in alcohols</li> </ul> | Must identify the bond and give the wavenumber range<br><br>Allow peak at $\sim 3375 \text{ cm}^{-1}$ | 1    |

| Question number | Answer                                                                                                                                                                                       | Additional guidance            | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------|
| 22(a)(ii)       | <ul style="list-style-type: none"> <li>not possible - All three contain the same bonds or possible - the fingerprint regions differ/by comparing the spectra to reference spectra</li> </ul> | No mark for unjustified answer | 1    |

| Question number | Answer                                                                                       | Additional guidance                                                                       | Mark |
|-----------------|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|------|
| 22(b)(i)        | <ul style="list-style-type: none"> <li>(all show) parent/molecular ion peak at 74</li> </ul> | Allow peak furthest to the right/highest m/z peak at 74<br>Do not award just 'peak at 74' | 1    |

| Question number | Answer                                                                                                                                                                                                                                       | Additional guidance                | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|------|
| 22(b)(ii)       | <ul style="list-style-type: none"> <li>fragment <math>^+\text{CH}_3\text{CHOH} = 45</math> (1)</li> <li>fragment <math>^+\text{CH}_2\text{OH} = 31</math> (1)</li> <li>fragment <math>^+(\text{CH}_3)_2\text{COH} = 59</math> (1)</li> </ul> | Ignore missing charge on fragments | 3    |

| Question number | Answer                |                           |                                               | Additional guidance                                                                                        | Mark |
|-----------------|-----------------------|---------------------------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------|------|
| 22(c)(i)        | Organic compound used | Name of oxidation product | Structural formula of oxidation product       | Allow displayed or skeletal formulae<br><br>1 mark for 2 correct names and 1 mark for each correct formula | 3    |
|                 | A                     | Butanone<br>and           | $\text{CH}_3\text{CH}_2\text{COCH}_3$         |                                                                                                            |      |
|                 | B                     | Butanal (1)               | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ |                                                                                                            |      |

| Question number | Answer                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 22(c)(ii)       | <p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• reagent: Benedict's/Fehling's</li> <li>• (oxidation product of) compound A: no change</li> <li>• (oxidation product of) compound B: (Benedict's/Fehlings test) red precipitate.</li> </ul> | <p>(1) Allow Tollens' or iodine + alkali</p> <p>(1)</p> <p>(1) (Tollens' reagent) silver mirror with (oxidation product of) B. No reaction with (oxidation product of) A</p> <p>(iodine + alkali) yellow precipitate (iodoform) with (oxidation product of) A. No reaction with oxidation product of B</p> <p>If (butanoic) acid in (c)(i), allow reagent: sodium carbonate/sodium hydrogencarbonate (solution)</p> <p>Observations: (oxidation product of) compound B: bubbles/fizzes</p> | 3    |

| Question number | Answer                                                                                                  | Additional guidance                                                                                  | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|------|
| 23(a)           | <ul style="list-style-type: none"> <li>balanced equation (1)</li> <li>all states correct (1)</li> </ul> | $\text{I}_2(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{ICl}(\text{l})$<br>Accept multiples | 2    |

| Question number | Answer                                                                                                        | Additional guidance                                                                                             | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------|
| 23(b)           | <ul style="list-style-type: none"> <li>correct electronegativity values and correct dipole diagram</li> </ul> | $\text{Cl} = 3.0$ and $\text{I} = 2.5$<br>$\delta^+ \text{I} - \text{Cl} \delta^-$<br>Do not award full charges | 1    |

| Question number | Answer                                                                        | Additional guidance                                                                                                                     | Mark |
|-----------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------|
| 23(c)(i)        | <ul style="list-style-type: none"> <li>1 mark each correct formula</li> </ul> | <br>Allow 1 mark for 2 correct non-skeletal formulae | 2    |

| Question number | Answer                                                                                                                                                                                                                                                                                                                 | Additional guidance    | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------|
| 23(c)(ii)       | An explanation that makes reference to the following points:<br><br><ul style="list-style-type: none"> <li>• identification of correct isomer (1)</li> <li>• iodine is <math>\delta^+</math> and is attacked by the <math>\pi</math> electrons (1)</li> <li>• more stable secondary carbocation formed. (1)</li> </ul> | 2-chloro-1-iodopropane | 3    |

| Question number | Answer                                                                                                                                                                              | Additional guidance                                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|------|
| 23(d)(i)        | An answer that makes reference to the following points:<br><br><ul style="list-style-type: none"> <li>• carry out in fume cupboard (1)</li> <li>• chlorine is toxic. (1)</li> </ul> | Allow fume hood or similar description<br><br>Do not allow 'harmful' | 2    |

| Question number | Answer                                                                                                 | Additional guidance      | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------|--------------------------|------|
| 23(d)(ii)       | <ul style="list-style-type: none"> <li>• I in ICl = +1</li> <li>• I in ICl<sub>3</sub> = +3</li> </ul> | Both needed for the mark | 1    |

| Question number | Answer                                                                                                                                                                                     | Additional guidance | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 23(d)(iii)      | <ul style="list-style-type: none"> <li>• +5 and -1 to -1 (and -1) (1)</li> <li>• not disproportionation because the chlorine has not undergone both oxidation and reduction (1)</li> </ul> |                     | 2    |

| Question number | Answer                                                                                              | Additional guidance                                                                                                 | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|------|
| 23(e)(i)        | <ul style="list-style-type: none"> <li>correct method (1)</li> <li>answer with units (1)</li> </ul> | $\text{Cl}_2 = 2 \times 35.5 = 71$<br>$71 \div 24000$<br>$= 0.0029583 \text{ g cm}^{-3}$<br>$= 3 \text{ g dm}^{-3}$ | 2    |

| Question number | Answer                                                                                                                                                                                                                                                                                                    | Additional guidance | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 23(e)(ii)       | <p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>chlorine (gas) is more dense than air (1)</li> <li>chlorine (gas) removed (from the equilibrium) (1)</li> <li>position of equilibrium moves to the LHS (more brown liquid/ICl). (1)</li> </ul> |                     | 3    |

| Question number | Answer                                                                                                                                                      | Additional guidance                                                                                                                                                                     | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 23(f)           | <ul style="list-style-type: none"> <li>calculation of mols of iodine and fluorine (1)</li> <li>calculation of whole number ratio and formula (1)</li> </ul> | $\text{Mols of iodine} = 0.64 \div 126.9 = 5.04 \times 10^{-3}$<br>$\text{Mols of fluorine} = (1.31 - 0.64) \div 19 = 3.53 \times 10^{-2}$<br>Ratio 1:7 therefore formula $\text{IF}_7$ | 2    |