

# Mark Scheme (Results)

June 2014

GCE Chemistry 6CH05/01

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Summer 2014

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:
  - i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  - ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  - iii) organise information clearly and coherently, using specialist vocabulary when appropriate

## Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

### Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

**Section A (multiple choice)**

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>1</b>        | D              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>2</b>        | C              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>3</b>        | C              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>4</b>        | C              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>5</b>        | D              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>6 (a)</b>    | B              |        | <b>1</b> |
| <b>6 (b)</b>    | C              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>7</b>        | D              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>8</b>        | D              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>9</b>        | C              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>10</b>       | A              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>11</b>       | A              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>12</b>       | B              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>13</b>       | B              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>14 (a)</b>   | A              |        | <b>1</b> |
| <b>14 (b)</b>   | D              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>15</b>       | A              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>16</b>       | C              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>17</b>       | D              |        | <b>1</b> |

| Question Number | Correct Answer | Reject | Mark     |
|-----------------|----------------|--------|----------|
| <b>18</b>       | B              |        | <b>1</b> |

## Section B

| Question Number  | Acceptable Answers                                                                                                                                                                                               | Reject                               | Mark     |
|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|----------|
| <b>19 (a)(i)</b> | So that only the water formed in the combustion is absorbed by X / measured.<br><br>ALLOW<br>'reacts with X' for 'absorbed by X'<br><br>OR<br>Otherwise the mass / amount of the water measured will be too high | Reacts with A<br><br>References to Y | <b>1</b> |

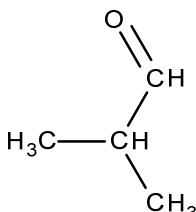
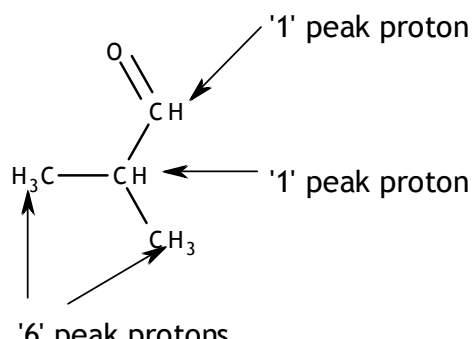
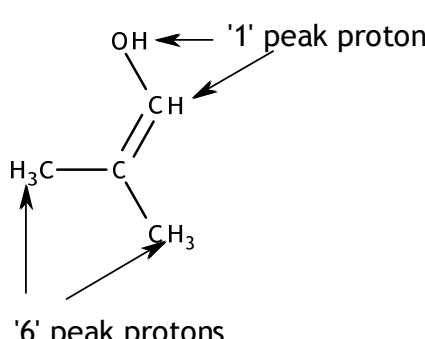
| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                             | Reject                                                                                       | Mark     |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|----------|
| <b>19 (a)(ii)</b> | (Anhydrous) Calcium chloride / $\text{CaCl}_2$ / Magnesium sulphate / $\text{MgSO}_4$ / silica gel / sodium sulphate / $\text{Na}_2\text{SO}_4$<br><br>ALLOW<br>Phosphorus(V) oxide / phosphorus pentoxide / $\text{P}_4\text{O}_{10}$ / $\text{P}_2\text{O}_5$ / Silica beads | Sulfuric acid<br>Calcium oxide<br>Silica / $\text{SiO}_2$<br>anhydrous<br>copper(II) sulfate | <b>1</b> |

| Question Number    | Acceptable Answers                                                                                                                                                                                                                             | Reject    | Mark     |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------|
| <b>19 (a)(iii)</b> | Soda lime<br><br>OR<br><br>calcium hydroxide / $\text{Ca}(\text{OH})_2$<br><b>and</b><br>sodium hydroxide / $\text{NaOH}$<br><br>ALLOW<br>sodium hydroxide / $\text{NaOH}$ / potassium hydroxide / $\text{KOH}$ / Calcium oxide / $\text{CaO}$ | Limewater | <b>1</b> |

| Question Number             | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reject | Mark     |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>19</b><br><b>(a)(iv)</b> | <p>The methods below illustrate the allocation of marks. But the first four marks may be scored by any correct method.</p> <p><b>Method 1</b></p> <p>mol CO<sub>2</sub> = 8.8/44 = 0.2 (= mol C) <b>(1)</b></p> <p>mol H<sub>2</sub>O = 3.6/18 = 0.2<br/>mol H = 2 x mol H<sub>2</sub>O = 0.4 <b>(1)</b></p> <p>mass O = 3.6 - (12 x 0.2 + 1 x 0.4)<br/>= 0.8 (g) <b>(1)</b></p> <p>mol O = 0.8/16 = 0.05 <b>(1)</b></p> <p><b>Method 2</b></p> <p>Mass H = 3.60 x 2/18 = 0.40 (g)<br/>= 0.40 / 1 = 0.40 (mol) <b>(1)</b></p> <p>Mass C = 8.80 x 12/44 = 2.4 (g)<br/>= 2.4 / 12 = 0.20 (mol) <b>(1)</b></p> <p>Mass O = 3.60 - (0.40 + 2.4) = 0.80(g) <b>(1)</b><br/>= 0.80 / 16 = 0.05 (mol) <b>(1)</b></p> <p>Empirical formula = C<sub>4</sub>H<sub>8</sub>O <b>(1)</b></p> <p>TE on incorrect moles but the ratio <b>must</b> be whole number</p> <p>IGNORE use of O<sub>2</sub> for O in the 'words'</p> <p>Correct empirical formula with some working at each stage scores full marks<br/><b>but</b><br/>Correct empirical formula with <b>no</b> working or <b>unclear and non-scoring</b> working scores final mark only</p> |        | <b>5</b> |

| Question Number  | Acceptable Answers                                                                                                                                  | Reject                                                  | Mark     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|----------|
| <b>19 (b)(i)</b> | (Molecular ion is $m/e =$ ) 72 (= $M_r$ of <b>A</b> )( <b>1</b> )<br>Molecular formula = $C_4H_8O$ ( <b>1</b> )<br>No TE on incorrect molecular ion | Structural<br>Or<br>Displayed<br>Or<br>Molecular<br>ion | <b>2</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Reject | Mark     |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>19 (b)(ii)</b> | Any three of (1 mark for each structure)<br><div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <math>\begin{array}{c} CH_2^+ \\   \\ H_3C-CH_2 \end{array}</math> </div> <div style="text-align: center;"> <math>\begin{array}{c} CH_3 \\   \\ H_3C-CH^+ \end{array}</math> </div> <div style="text-align: center;"> <math>\begin{array}{c} O \\    \\ H_3C-C^+ \end{array}</math> </div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="text-align: center;"> <math>\begin{array}{c} O \\    \\ ^+CH_2-CH \end{array}</math> </div> <div style="text-align: center;"> <math>\begin{array}{c} OH \\   \\ H_2C=C^+ \end{array}</math> </div> <div style="text-align: center;"> <math>\begin{array}{c} OH \\   \\ ^+CH=CH \end{array}</math> </div> </div> ALLOW structural formulae (eg $CH_3CO^+$ )<br>IGNORE Position of positive charge<br>Penalise omission of charge or negative charge once<br>$C_3H_7^+$ and /or $C_2H_3O^+$ scores 1 if no scoring structure |        | <b>3</b> |

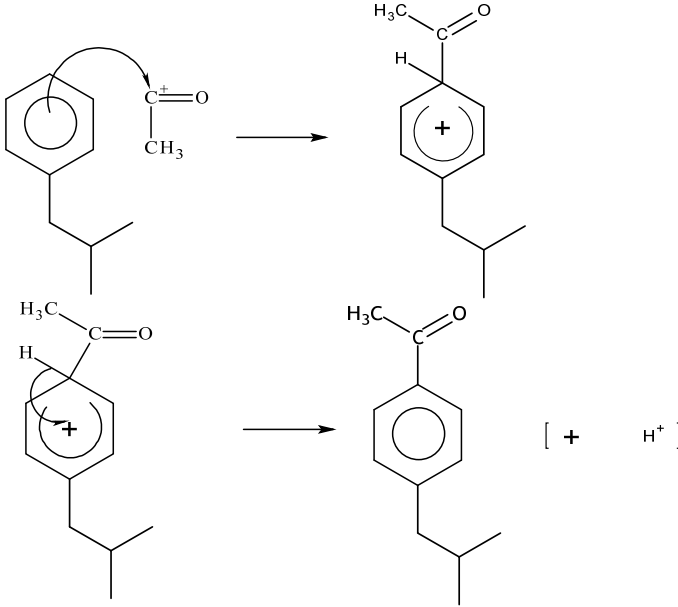
| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                            | Reject                                                                                                                                                                                                                                                                                                                                       | Mark |          |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------|
| *19 (c)         | <p>Structure of <b>A</b> (1)</p>  <p>Three (proton/H) environments (1)</p> <p><b>Identify</b> the 6 protons in one environment and 1 each in the other two (1)</p> <p>No TE on incorrect structures except propan-2-ol : scores MP3 only</p> | <p>OR diagram (1)</p>  <p>6 proton label (1) <b>both</b> 1 proton labels (1)</p> <p>ALLOW enol structure</p>  <p>6 proton label (1) <b>both</b> 1 proton labels (1)</p> |      | <b>3</b> |

**Total for Question 19 = 16 marks**

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                       | Reject | Mark     |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20 (a)(i)</b> | <p>Overall <b>yield</b> higher<br/>OR<br/>Reduces use of solvents (ALLOW chemicals / reactants)<br/>OR<br/>Less loss of chemicals<br/>OR<br/>Less waste products</p> <p>IGNORE<br/>References to Energy / fuel / CO<sub>2</sub><br/>References to atom economy<br/>More efficient conversion<br/>Fewer side products</p> |        | <b>1</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                              | Reject | Mark     |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20 (a)(ii)</b> | <p>Lowers (operating) temperature / energy (requirements)<br/>OR<br/>Less fuel needed</p> <p>IGNORE<br/>References to catalyst properties such as 'lowers E<sub>a</sub>', 'can be re-used'<br/>Atom economy</p> |        | <b>1</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                             | Reject | Mark     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20 (b)(i)</b> | <p><math>\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-</math></p> <p>Structural formulae not required<br/>Positive charge may be anywhere on the electrophile.<br/>IGNORE<br/>Curly arrows even if incorrect</p> |        | <b>1</b> |

| Question Number             | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reject | Mark     |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20</b><br><b>(b)(ii)</b> |  <p>TE on incorrect electrophile in (b)(i)</p> <p>If benzene used instead of substituted benzene<br/>OR<br/>If final product is not 1,4 only MP 1 and 2 can be scored</p> <p>Curly arrow from on or within the circle to positively charged carbon</p> <p>ALLOW<br/>Curly arrow from anywhere within the hexagon</p> <p>Arrow to <b>any</b> part of the electrophile including to the + charge (which can be anywhere on the electrophile) <b>(1)</b></p> <p>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, <b>and</b> facing the tetrahedral carbon <b>and</b> with some part of the positive charge within the horseshoe<br/>ALLOW dotted horseshoe <b>(1)</b></p> <p>Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a stable molecule <b>(1)</b></p> <p>Correct Kekulé structures score full marks<br/>Ignore any involvement of <math>\text{AlCl}_4^-</math> in the final step</p> |        | <b>3</b> |

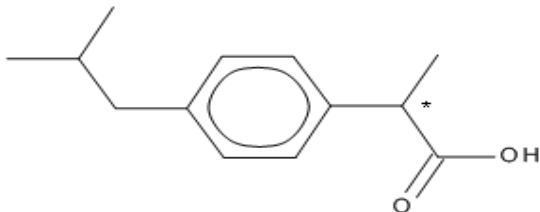
| Question Number    | Acceptable Answers                                                                                                                                                                                                                 | Reject   | Mark     |
|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|
| <b>20 (b)(iii)</b> | No HCl formed (as a by-product)<br>OR<br>Ethanoic acid easier to recover<br><br>ALLOW<br>Reverse arguments<br><br>IGNORE<br>Chlorine containing product<br>References to ozone layer, acid rain,<br>global warming<br>Atom economy | Chlorine | <b>1</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                | Reject | Mark     |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20 (c)(i)</b> | Catalyst (more) easily recovered /<br>separated OR can be filtered<br><br>OR<br>Facilitates the use of flow (rather than<br>batch) systems<br><br>IGNORE<br>references to properties of catalysts |        | <b>1</b> |

| Question Number             | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Reject                                                                                                                                                                                           | Mark |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>20</b><br><b>(c)(ii)</b> | <p><b>Reaction 1</b></p> <p>(red) phosphorus / P / P<sub>4</sub> and iodine / I<sub>2</sub><br/>ALLOW<br/>PI<sub>3</sub> / HI <b>(1)</b></p> <p><b>Reaction 3</b></p> <p>Hydrochloric acid / HCl(aq) or sulfuric acid / H<sub>2</sub>SO<sub>4</sub> (aq) <b>(1)</b></p> <p><b>and</b> reflux / heat <b>(1)</b></p> <p>Award second mark for<br/>Acid / H<sup>+</sup> / H<sub>3</sub>O<sup>+</sup> <b>and</b> reflux</p> <p>OR</p> <p>NaOH(aq) / KOH(aq) <b>(1)</b></p> <p>(reflux) <b>then</b> acidify with HCl(aq) or H<sub>2</sub>SO<sub>4</sub> (aq) <b>(1)</b></p> <p>IGNORE<br/>Omission of states throughout</p> | <p>NaI + H<sub>2</sub>SO<sub>4</sub></p> <p>PI<sub>5</sub></p> <p>Just H<sup>+</sup> / H<sub>3</sub>O<sup>+</sup></p> <p>reflux / heat<br/>without acid<br/>or with<br/>warm or<br/>&lt;50°C</p> |      |

| Question Number              | Acceptable Answers                                                                                                                                                                                                                                                                                                                                        | Reject                                                                                                 | Mark     |
|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------|
| <b>20</b><br><b>(c)(iii)</b> | <p>C=O / carbonyl group (only) in carboxylic acid / ibuprofen <b>(1)</b></p> <p>Absorption / peak<br/>at 1725 - 1700 (cm<sup>-1</sup>) <b>(1)</b></p> <p>If no other mark has been awarded,<br/>then ALLOW (for 1 mark)</p> <p>OH in both but<br/>in alcohol 3750 - 3200 (cm<sup>-1</sup>) but in<br/>carboxylic acids 3300 to 2500 (cm<sup>-1</sup>)</p> | <p>ketone</p> <p>1700 - 1680<br/>(cm<sup>-1</sup>)</p> <p>Single values<br/>rather than<br/>ranges</p> | <b>2</b> |

| Question Number  | Acceptable Answers                                                                                                                                                                                                                                                                                                                           | Reject                           | Mark     |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|----------|
| <b>20 (d)(i)</b> | <p>(A chiral molecule is) non-superimposable on its mirror image.</p> <p>ALLOW</p> <p>Asymmetric (tetrahedral) carbon atom / has a carbon atom bonded to <b>four</b> different groups / atoms</p> <p>IGNORE</p> <p>Has two enantiomers</p> <p>Functional (as in functional groups)</p> <p>Reference to rotation of plane polarized light</p> | molecules / species (for groups) | <b>1</b> |

| Question Number   | Acceptable Answers                                                                                                                   | Reject | Mark     |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20 (d)(ii)</b> |  <p>ALLOW any clear indication of chiral carbon</p> |        | <b>1</b> |

| Question Number    | Acceptable Answers                                                                                                                                                                                                       | Reject                                    | Mark     |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|----------|
| <b>20 (d)(iii)</b> | <p>(A racemic mixture is) an equimolar mixture of the two enantiomers / (optical) isomers</p> <p>ALLOW (for equimolar mixture) equal amounts / concentrations / volumes / proportions</p> <p>OR</p> <p>50:50 mixture</p> | Just 'no effect on plane polarised light' | <b>1</b> |

| Question Number             | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Reject | Mark     |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>20</b><br><b>(d)(iv)</b> | <p>Any two of</p> <ol style="list-style-type: none"> <li>1. All the ibuprofen is useful (rather than half)</li> <li>2. No need for separation of isomers / enantiomers</li> <li>3. No need for a more complex synthesis forming just one enantiomer</li> <li>4. Sometimes one enantiomer has negative effects</li> <li>5. Smaller dosage may be used</li> </ol> <p>ALLOW (For point 4 above)<br/>Dose / inactive isomer is less likely to be harmful</p> <p>IGNORE<br/>Reference to cost / yield / atom economy / side effects</p> |        | <b>2</b> |

**Total for Question 20 = 18 marks**

| Question Number  | Acceptable Answers                                                                                                                                                              | Reject                                      | Mark     |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|----------|
| <b>21 (a)(i)</b> | $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Fe}^{2+} \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$ <p>Ignore state symbols even if incorrect</p> | Any answers with electrons even if balanced | <b>1</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Reject | Mark     |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21 (a)(ii)</b> | <p>Ignore SF except 1 SF – penalise this and/or rounding errors once only in (a)(ii) – (v)</p> <p>Moles of <math>\text{Fe}^{2+}</math> reacting in titration<br/> <math>= 23.85 \times 10^{-3} \times 0.255</math><br/> <math>= 6.08175 \times 10^{-3} \text{ mol} *</math> <b>(1)</b></p> <p>Moles of <math>\text{Cr}_2\text{O}_7^{2-}</math> that reacted in titration<br/> <math>= \text{answer} * \div 6</math><br/> <math>= 6.08175 \times 10^{-3} \div 6</math><br/> <math>= 1.013625 \times 10^{-3} \text{ mol}</math> <b>(1)</b></p> <p>Correct answer with no working scores 2</p> |        | <b>2</b> |

| Question Number    | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Reject | Mark     |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21 (a)(iii)</b> | <p>Moles of <math>\text{Cr}_2\text{O}_7^{2-}</math> at start<br/> <math>= 25 \times 10^{-3} \times 0.200</math><br/> <math>= 5 \times 10^{-3} \text{ mol}^{**}</math> <b>(1)</b></p> <p>Moles of <math>\text{Cr}_2\text{O}_7^{2-}</math> that reacted with ethanol<br/> <math>= \text{answer}^{**} - \text{answer } 21(a)(ii)</math><br/> <math>= 5 \times 10^{-3} - 1.013625 \times 10^{-3}</math><br/> <math>= 3.986375 \times 10^{-3} \text{ mol}</math> <b>(1)</b></p> <p>Correct answer with no working scores 2</p> |        | <b>2</b> |

| Question Number             | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                                                                                                          | Mark     |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|----------|
| <b>21</b><br><b>(a)(iv)</b> | $\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COOH} + 4\text{H}^+ + 4\text{e}^- \quad (1)$ <p>3 mol of ethanol needs 12 mol electrons supplied by<br/>2 mol potassium dichromate(VI)</p> <p>ALLOW<br/>Use of oxidation numbers of C and Cr<br/>OR<br/>Use of ratio of electrons lost and gained<br/>OR<br/>Balanced equation:<br/> <math display="block">3\text{CH}_3\text{CH}_2\text{OH} + 2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ \rightarrow 3\text{CH}_3\text{COOH} + 4\text{Cr}^{3+} + 11\text{H}_2\text{O} \quad (1)</math> </p> <p>IGNORE<br/>Uncancelled species including the 12 electrons in the last equation</p> | <p>Use of [O]</p> <p><b>Just</b> 3 mol of ethanol reacts with 2 mol <math>\text{Cr}_2\text{O}_7^{2-}</math></p> | <b>2</b> |

| Question Number            | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Reject | Mark     |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>21</b><br><b>(a)(v)</b> | <p>Moles of ethanol that reacted with potassium dichromate(VI)<br/> = ans. 21(a)(iii) <math>\times 3 \div 2</math><br/> = <math>5.9795625 \times 10^{-3} \text{ mol}</math> <span style="float: right;"><b>(1)</b></span></p> <p>Concentration in <b>Q</b><br/> = previous answer <math>\times 10 \times 40</math><br/> = <math>2.391825 \text{ mol dm}^{-3}</math> <span style="float: right;"><b>(2)</b></span></p> <p>(1 mark for <math>\times 10</math> or <math>\times 40</math> and 1 mark for completion of calculation)</p> <p>Correct answer with no working scores 3</p> |        | <b>3</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Reject | Mark     |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>*21(b)</b>   | <p><math>\text{Fe}^{2+}</math> / iron(II) <b>(1)</b></p> <p>And any TWO of:</p> <p>Barium diphenylamine sulfonate is a <b>redox</b> indicator</p> <p>ALLOW<br/>reaction is <b>redox</b> <b>(1)</b></p> <p>Barium diphenylamine sulfonate / indicator is reduced by iron(II)</p> <p>OR<br/>Iron(II) is oxidized by barium diphenylamine sulfonate / indicator</p> <p>OR<br/>Barium diphenylamine sulfonate / indicator oxidized by potassium dichromate(VI)</p> <p>OR<br/>Potassium dichromate(VI) is reduced by Barium diphenylamine sulfonate / indicator <b>(1)</b></p> <p>The oxidized form / oxidation product of barium diphenylamine sulfonate is purple<br/>OR<br/>the reduced form is colourless</p> <p>ALLOW<br/>Oxidised and reduced form of the indicator have different colours <b>(1)</b></p> |        | <b>3</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Reject                                                                                   | Mark     |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------|
| <b>*21(c)</b>   | <p><b>EITHER</b></p> <p><b>MP1</b><br/>Difficult to know when reaction is complete</p> <p>OR<br/>Difficult to know when all the ethanol has been oxidized (to ethanoic acid)</p> <p>OR<br/>Some ethanol only oxidized to ethanal</p> <p>ALLOW<br/>Some ethanol is oxidized by air <b>(1)</b></p> <p><b>MP2</b> (depends on MP1 correct or 'ethanol evaporates')<br/>So less potassium dichromate(VI) will be used up <b>(1)</b></p> <p><b>MP3</b> (depends on MP1 or MP2 or 'ethanol evaporates')<br/>Ethanol concentration will appear low <b>(1)</b></p> <p><b>OR</b><br/>Other compounds in the fermented solution (e.g. aldehydes) are oxidized also. <b>(1)</b></p> <p>So more potassium dichromate(VI) will be used up <b>(1)</b></p> <p>Ethanol concentration will appear high <b>(1)</b></p> | <p>Ethanol evaporates<br/>Transfer losses / spillages</p> <p>Not all sugar fermented</p> | <b>3</b> |

**Total for Question 21 = 16 marks**  
**Total for Section B = 50 marks**

### Section C

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                               | Reject                                                                              | Mark     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|----------|
| <b>22 (a)</b>   | <p>Oxygen atoms in water molecules have <math>\delta^-</math> charge. <b>(1)</b></p> <p>Which form electrostatic / ion-dipole attractions with sodium (ion). <b>(1)</b></p> <p>ALLOW for one mark<br/>copper(II) ions form dative covalent bonds but sodium ions do not (<b>both</b> needed)</p> | <p>Ionic bonds / attractions</p> <p>Intermolecular forces</p> <p>Hydrogen bonds</p> | <b>2</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                | Reject                                 | Mark     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|----------|
| <b>22 (b)</b>   | <p>Additional (dative covalent bond) lone pairs are accommodated in vacant (3)d orbitals / (3)d sub-shell</p> <p>ALLOW<br/>Vacant <b>higher</b> energy orbitals / sub-shells<br/>IGNORE 3s/3p</p> | <p>'Partially filled' for 'vacant'</p> | <b>1</b> |



| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Reject                 | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------|
| <b>22 (d)</b>   | <p><b>Method 1: cell emfs</b></p> <p>For the reaction<br/> <math>\text{Cu}(\text{H}_2\text{O})_6^{2+}(\text{aq}) + 2\text{S}_2\text{O}_3^{2-}(\text{aq}) \rightarrow \text{Cu}(\text{s}) + 6\text{H}_2\text{O}(\text{l}) + \text{S}_4\text{O}_6^{2-}(\text{aq})</math> *</p> <p><math>E^\circ_{\text{cell}} = +0.34 - 0.09 = (+)0.25 \text{ (V)}</math><br/> <b>and</b><br/>         (Positive so) reaction is feasible <b>(1)</b></p> <p>For the reaction<br/> <math>\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4^{2+}(\text{aq}) + 2\text{S}_2\text{O}_3^{2-}(\text{aq}) \rightarrow \text{Cu}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{NH}_3(\text{aq}) + \text{S}_4\text{O}_6^{2-}(\text{aq})</math> **</p> <p><math>E^\circ_{\text{cell}} = -0.05 - 0.09 = -0.14 \text{ (V)}</math><br/> <b>and</b><br/>         (Negative so) reaction is not feasible <b>(1)</b></p> <p>If both values correct but feasibility omitted or incorrect award 1 mark</p> <p><b>Both</b> equations (* &amp; **) correct<br/>         IGNORE<br/>         Omission of H<sub>2</sub>O and states from the equations <b>(1)</b></p> <p><b>Method 2: anticlockwise rule</b></p> <p>Place the reactions in order of increasing (more positive) <math>E^\circ</math> values and check which reaction occurs in the anticlockwise direction. <b>(1)</b></p> <div style="display: flex; align-items: center;"> <div style="flex-grow: 1;"> <math>\text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{e}^- \rightarrow 2\text{S}_2\text{O}_3^{2-}(\text{aq}) \quad E^\circ = +0.09 \text{ V}</math> <math>\text{Cu}(\text{H}_2\text{O})_6^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s}) + 6\text{H}_2\text{O}(\text{l}) \quad E^\circ = 0.34 \text{ V}</math> </div> </div> <p>Reaction is feasible (desired reaction proceeds in anticlockwise direction) <b>(1)</b></p> <div style="display: flex; align-items: center; margin-top: 20px;"> <div style="flex-grow: 1;"> <math>\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{NH}_3(\text{aq}) \quad E^\circ = -0.05 \text{ V}</math> <math>\text{S}_4\text{O}_6^{2-}(\text{aq}) + 2\text{e}^- \rightarrow 2\text{S}_2\text{O}_3^{2-}(\text{aq}) \quad E^\circ = +0.09 \text{ V}</math> </div> </div> <p>Reaction is not feasible (proceeds in the opposite direction). <b>(1)</b></p> | electrons in equations | <b>3</b> |

| Question Number  | Acceptable Answers               | Reject | Mark     |
|------------------|----------------------------------|--------|----------|
| <b>22 (e)(i)</b> | (coordination number =) 4 / four |        | <b>1</b> |

| Question Number   | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reject | Mark     |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>22 (e)(ii)</b> | <p>Amount of complex = <math>4.82 / 288.7</math><br/> <math>(= 0.0166955 \text{ mol})</math><br/> Mass of nickel = <math>58.7 \times 4.82 / 288.7</math><br/> <math>= 0.98003 \text{ g}</math> <b>(1)</b></p> <p>% Nickel in alloy = <math>100 \times 0.98 / 1.02</math><br/> <math>= 96.08 \%</math> <b>(1)</b></p> <p>Correct answer with no working scores 2<br/> Ignore SF except 1</p> <p>ALLOW<br/> TE unless % &gt; 100</p> <p>Use of <math>A_r(\text{Ni}) = 59</math> (gives 96.57%)</p> |        | <b>2</b> |

| Question Number | Acceptable Answers                                                     | Reject | Mark     |
|-----------------|------------------------------------------------------------------------|--------|----------|
| <b>22 (f)</b>   | Nickel carbonyl is a gas (so can be easily separated from impurities). |        | <b>1</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reject | Mark     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------|
| <b>22 (g)</b>   | <p>Silver(I) oxide is precipitated in alkaline solution<br/> OR<br/> Silver(I) ions need to be in solution<br/> OR<br/> (Ammonia) prevents precipitation of silver(I) oxide <b>(1)</b></p> <p>Formation of diamminesilver(I) lowers concentration of <math>\text{Ag}^+(\text{aq})</math><br/> OR<br/> Equilibrium 2 shifts to the right by addition of ammonia <b>(1)</b></p> <p>(lower <math>[\text{Ag}^+]</math>) causes equilibrium 1 to shift to the left <b>(1)</b></p> <p>IGNORE Omission of oxidation state of silver</p> |        | <b>3</b> |

**Total for Question 22 = 20 marks**

**Total for Section C = 20 marks**

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