

# A-level Chemistry

Paper 2 (7405/2): Organic and Physical Chemistry  
Mark scheme

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7405  
Specimen paper

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Version 0.5

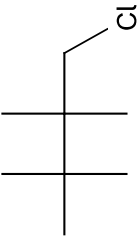
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| Question | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                     | Mark                       | AO                                        | Comments                                                                       |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------------|--------------------------------------------------------------------------------|
| 01.1     | <p>Consider experiments 1 and 2: [B constant]<br/> [A] increases × 3: rate increases by 3<sup>2</sup> therefore 2nd order with respect to A</p> <p>Consider experiments 2 and 3:<br/> [A] increases × 2: rate should increase × 2<sup>2</sup> but only increases × 2<br/> Therefore, halving [B] halves rate and so 1st order with respect to B</p> <p>Rate equation: rate = k[A]<sup>2</sup>[B]</p> | <p>1</p> <p>1</p> <p>1</p> | <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1b</p> |                                                                                |
| 01.2     | <p>rate = k [C]<sup>2</sup>[D] therefore <math>k = \text{rate} / [\text{C}]^2[\text{D}]</math></p> <p><math>k = \frac{7.2 \times 10^{-4}}{(1.9 \times 10^{-2})^2 \times (3.5 \times 10^{-2})} = 57.0</math></p> <p>mol<sup>-2</sup> dm<sup>+6</sup> s<sup>-1</sup></p>                                                                                                                               | <p>1</p> <p>1</p> <p>1</p> | <p>AO2h</p> <p>AO2h</p> <p>AO2h</p>       | <p>Allow consequential marking on incorrect transcription</p> <p>Any order</p> |
| 01.3     | <p>rate = <math>57.0 \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2} = 3.99 \times 10^{-3}</math> (mol dm<sup>-3</sup> s<sup>-1</sup>)</p> <p><b>OR</b></p> <p>Their <math>k \times (3.6 \times 10^{-2})^2 \times 5.4 \times 10^{-2}</math></p>                                                                                                                                              | 1                          | AO2h                                      |                                                                                |

|      |                                                                                                                                                                                 |             |                      |                                                                                              |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------------------------------------------------------------------------------------------|
| 01.4 | Reaction occurs when molecules have $E \geq E_a$<br>Doubling T causes <u>many</u> more molecules to have this $E$<br>Whereas doubling [E] only doubles the number with this $E$ | 1<br>1<br>1 | AO1a<br>AO1a<br>AO1a |                                                                                              |
| 01.5 | $E_a = RT(\ln A - \ln k)/1000$<br>$E_a = 8.31 \times 300 (23.97 - (-5.03))/1000 = 72.3 \text{ (kJ mol}^{-1}\text{)}$                                                            | 1<br>1      | AO1b<br>AO1b         | Mark is for rearrangement of equation and factor of 1000 used correctly to convert J into kJ |

| Question | Marking guidance               | Mark | AO     | Comments                                                         |
|----------|--------------------------------|------|--------|------------------------------------------------------------------|
| 02.1     | <p>Gradient drawn on graph</p> | 1    | AO3 1a | Line must touch the curve at 0.012 but must not cross the curve. |

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                              |                                                                       |                                                                                  |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 02.2 | <p>Stage 1: Rate of reaction when concentration = <math>0.0120 \text{ mol dm}^{-3}</math><br/> From the tangent<br/> Change in [butadiene] = <math>-0.0160 - 0</math> and change in time = <math>7800 - 0</math><br/> Gradient = <math>-(0.0160 - 0)/(7800 - 0) = -2.05 \times 10^{-6}</math><br/> Rate = <math>2.05 \times 10^{-6} \text{ (mol dm}^{-3} \text{ s}^{-1}\text{)}</math></p> <p>Stage 2: Comparison of rates and concentrations<br/> Initial rate/rate at <math>0.0120 = (4.57 \times 10^{-6})/(2.05 \times 10^{-6}) = 2.23</math><br/> Initial concentration/concentration at point where tangent drawn = <math>0.018/0.012 = 1.5</math></p> <p>Stage 3: Deduction of order<br/> If order is 2, rate should increase by factor of <math>(1.5)^2 = 2.25</math> this is approximately equal to 2.23 therefore order is 2nd with respect to butadiene</p> | <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> | <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1b</p> | <p>Extended response</p> <p>Marking points in stage 2 can be in either order</p> |
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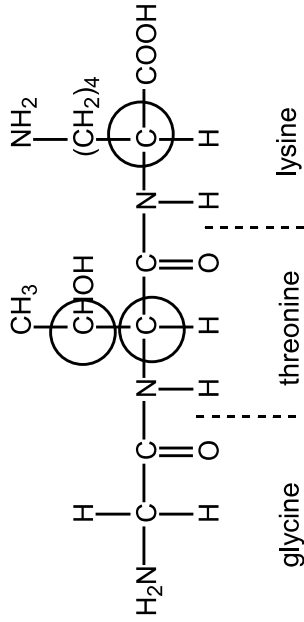
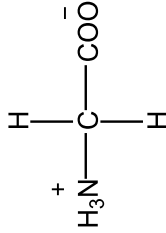
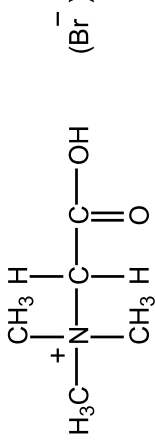
| Question | Marking guidance                                                                                                                                                                                       | Mark       | AO               | Comments |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------------|----------|
| 03.1     | 2,2,4-trimethylpentane                                                                                                                                                                                 | 1          | AO1a             |          |
| 03.2     | 5                                                                                                                                                                                                      | 1          | AO2b             |          |
| 03.3     | $C_{20}H_{42} \longrightarrow C_8H_{18} + 2C_3H_6 + 3C_2H_4$                                                                                                                                           | 1          | AO2b             |          |
| 03.4     | Mainly alkenes formed                                                                                                                                                                                  | 1          | AO1b             |          |
| 03.5     | 4 (monochloro isomers)<br>$  \begin{array}{ccccccc}  & & CH_3 & H & & CH_3 & \\  & &   &   & &   & \\  H_3C & - & C & - & C & - & CH_3 \\  & &   &   & &   & \\  & & H & & Cl & & CH_3  \end{array}  $ | 1<br><br>1 | AO2b<br><br>AO2a |          |
| 03.6     |                                                                                                                   | 1          | AO2a             |          |

|      |                                                                                                                                                                                                                                                                                                                  | Both required |      |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------|
| 03.7 | $\text{C}_8\text{H}_{17}^{35}\text{Cl} = 96.0 + 17.0 + 35.0 = 148.0$ <p>and <math>\text{C}_8\text{H}_{17}^{37}\text{Cl} = 96.0 + 17.0 + 37.0 = 150.0</math></p> $M_r \text{ of this } \text{C}_8\text{H}_{17}\text{Cl} = \frac{1.5 \times 148.0}{2.5} + \frac{(1.0 \times 150.0)}{2.5} = 148.8$                  | 1             | AO1b |
|      |                                                                                                                                                                                                                                                                                                                  | 1             | AO1b |
| 03.8 | $\frac{24.6}{12} \quad \frac{2.56}{1} \quad \frac{72.8}{35.5} = 2.05 : 2.56 : 2.05$ <p>Simplest ratio = <math>\frac{2.05}{2.05} : \frac{2.56}{2.05} : \frac{2.05}{2.05}</math></p> <p>= 1 : 1.25 : 1</p> <p>Whole number ratio (× 4) = 4 : 5 : 4</p> <p>MF = <math>\text{C}_8\text{H}_{10}\text{Cl}_8</math></p> | 1             | AO2b |
|      |                                                                                                                                                                                                                                                                                                                  | 1             | AO2b |
|      |                                                                                                                                                                                                                                                                                                                  | 1             | AO2b |

| Question | Marking guidance                                                                                                                                       | Mark | AO   | Comments                                                   |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------------------------------------------------------------|
| 04.1     | 3-methylbutan-2-ol                                                                                                                                     | 1    | AO1a |                                                            |
| 04.2     | $  \begin{array}{c}  \text{CH}_3 \\    \\  \text{H}_3\text{C}-\text{C}-\text{C}-\text{CH}_3 \\    \quad    \\  \text{H} \quad \text{O}  \end{array}  $ | 1    | AO2g | Allow (CH <sub>3</sub> ) <sub>2</sub> CHCOCH <sub>3</sub>  |
| 04.3     | Elimination                                                                                                                                            | 1    | AO1a |                                                            |
| 04.4     | $  \begin{array}{c}  \text{CH}_3 \\    \\  \text{H}_3\text{C}-\text{C}=\text{C}-\text{CH}_3 \\    \\  \text{H}  \end{array}  $                         | 1    | AO2g | Allow (CH <sub>3</sub> ) <sub>2</sub> C=CHCH <sub>3</sub>  |
|          | $  \begin{array}{c}  \text{CH}_3 \\    \\  \text{H}_3\text{C}-\text{C}-\text{C}=\text{CH}_2 \\    \quad   \\  \text{H} \quad \text{H}  \end{array}  $  | 1    | AO2g | Allow (CH <sub>3</sub> ) <sub>2</sub> CHCH=CH <sub>2</sub> |

|      |                                                                                                                         |   |        |                                                                  |
|------|-------------------------------------------------------------------------------------------------------------------------|---|--------|------------------------------------------------------------------|
| 04.5 | Position                                                                                                                | 1 | AO1a   |                                                                  |
| 04.6 | C B A                                                                                                                   | 1 | AO3 1b |                                                                  |
| 04.7 | $\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_3\text{C}-\text{C}-\text{CH}_2\text{CH}_3 \\   \\ \text{OH} \end{array}$ | 1 | AO2g   | Allow $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}_2\text{CH}_3$ |
| 04.8 | $\begin{array}{c} \text{CH}_3 \\   \\ \text{H}_3\text{C}-\text{C}-\text{CH}_2\text{OH} \\   \\ \text{CH}_3 \end{array}$ | 1 | AO2e   | Allow $(\text{CH}_3)_3\text{CCH}_2\text{OH}$                     |

| Question | Marking guidance                                                                                                                                                                                                                                                                    | Mark                                | AO                                              | Comments |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------------------|----------|
| 05.1     | Secondary                                                                                                                                                                                                                                                                           | 1                                   | AO1a                                            |          |
| 05.2     | <p>Nitrogen and oxygen are very electronegative</p> <p>Therefore, C=O and N–H are polar</p> <p>Which results in the formation of a hydrogen bond between O and H</p> <p>In which a lone pair of electrons on an oxygen atom is strongly attracted to the <math>\delta^+</math>H</p> | <p>1</p> <p>1</p> <p>1</p> <p>1</p> | <p>AO1a</p> <p>AO1a</p> <p>AO1a</p> <p>AO1a</p> |          |

| Question | Marking guidance                                                                                                                                              | Mark | AO   | Comments                                                                                          |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|---------------------------------------------------------------------------------------------------|
| 06.1     |  <p>glycine                      threonine                      lysine</p> | 1    | AO2a |                                                                                                   |
| 06.2     |                                                                            | 1    | AO2a |                                                                                                   |
| 06.3     |  <p>(Br<sup>-</sup>)</p>                                                  | 1    | AO2a | Allow<br>(CH <sub>3</sub> ) <sub>3</sub> N <sup>+</sup> —CH <sub>2</sub> —COOH (Br <sup>-</sup> ) |
| 06.4     | 2-amino-3-hydroxybutanoic acid                                                                                                                                | 1    | AO2a |                                                                                                   |

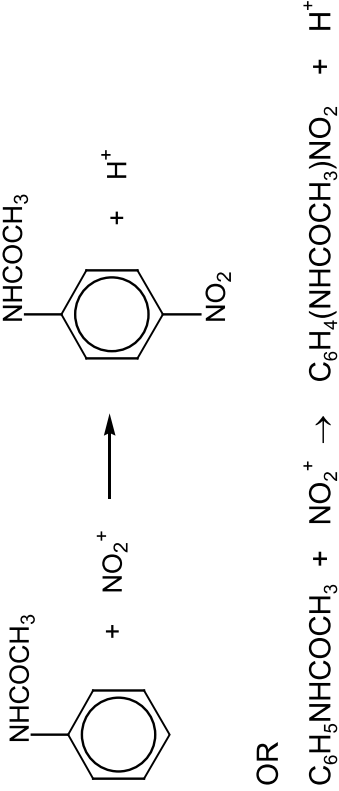
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| 06.5 | $  \begin{array}{c}  \text{NH}_3^+ \\    \\  (\text{CH}_2)_4 \\    \\  \text{H}_3\text{N}^+ - \text{C} - \text{COOH} \\    \\  \text{H}  \end{array}  $ | 1 | AO2a |  |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------|---|------|--|

| Question | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Mark        | AO                   | Comments |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------|
| 07.1     | $\begin{array}{c} \text{H} \quad \text{CH}_3 \\   \quad   \\ \text{C}=\text{C} \\   \quad   \\ \text{CH}_3 \quad \text{Cl} \end{array}$ <p>Addition</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1<br><br>1  | AO1a<br><br>AO1a     |          |
| 07.2     | $\begin{array}{c} \text{H} \quad \text{H} \\   \quad   \\ \text{HO}-\text{C}-\text{C}-\text{OH} \\   \quad   \\ \text{CH}_3 \quad \text{CH}_3 \end{array}$ $\begin{array}{c} \text{O} \quad \text{CH}_3 \quad \text{H} \quad \text{O} \\    \quad   \quad   \quad    \\ \text{HO}-\text{C}-\text{C}-\text{C}-\text{C}-\text{OH} \\   \quad   \quad   \\ \text{CH}_3 \quad \text{H} \end{array}$ <p>OR</p> $\begin{array}{c} \text{O} \quad \text{CH}_3 \quad \text{H} \quad \text{O} \\    \quad   \quad   \quad    \\ \text{Cl}-\text{C}-\text{C}-\text{C}-\text{C}-\text{Cl} \\   \quad   \quad   \\ \text{CH}_3 \quad \text{H} \end{array}$ | 1<br><br>1  | AO2e<br><br>AO2e     |          |
| 07.3     | <p><b>Q</b> is biodegradable</p> <p>Polar C=O group or <math>\delta^+</math> C in <b>Q</b> (but not in <b>P</b>)</p> <p>Therefore, can be attacked by nucleophiles (leading to breakdown)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1<br>1<br>1 | AO2g<br>AO2c<br>AO2c |          |

| Question | Marking guidance                                                                                                                                                                              | Mark             | AO                             | Comments                                                                                                                                                                                                                            |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 08.1     | 2-deoxyribose                                                                                                                                                                                 | 1                | AO1a                           |                                                                                                                                                                                                                                     |
| 08.2     | Base A<br>Top N–H forms hydrogen bonds to lone pair on O of guanine<br>The lone pair of electrons on N bonds to H–N of guanine<br>A lone pair of electrons on O bonds to lower H–N of guanine | 1<br>1<br>1<br>1 | AO3 1b<br>AO2a<br>AO2a<br>AO2a | If Base B stated, allow 1 mark only for response including hydrogen bonding<br><br>Allow all 4 marks for a correct diagram showing the hydrogen bonding<br><br>Students could also answer this question using labels on the diagram |
| 08.3     | Allow either of the nitrogen atoms with a lone pair NOT involved in bonding to cytosine                                                                                                       | 1                | AO2a                           |                                                                                                                                                                                                                                     |
| 08.4     | Use in very small amounts / target the application to the tumour                                                                                                                              | 1                | AO2e                           |                                                                                                                                                                                                                                     |

| Question | Marking guidance                                                                                       | Mark | AO   | Comments                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------|--------------------------------------------------------------------------------------------------------|------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 09.1     | <p>(nucleophilic) addition-elimination</p> <p>M2</p> <p>M3</p> <p>M4 for 3 arrows and lp</p> <p>M1</p> | 1    | AO1a | Not electrophilic addition-elimination<br>Allow C <sub>6</sub> H <sub>5</sub> or benzene ring<br>Allow attack by :NH <sub>2</sub> C <sub>6</sub> H <sub>5</sub><br>M2 not allowed independent of M1, but allow M1 for correct attack on C+<br>M3 for correct structure <u>with charges</u> but lone pair on O is part of M4<br>M4 (for three arrows and lone pair) can be shown in more than one structure |
|          |                                                                                                        | 4    | AO2a |                                                                                                                                                                                                                                                                                                                                                                                                            |

|      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                     |                                                 |                                                                                        |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------------------|----------------------------------------------------------------------------------------|
| 09.2 | <p><b>The minimum quantity of hot water was used:</b><br/>To ensure the hot solution would be saturated / crystals would form on cooling</p> <p><b>The flask was left to cool before crystals were filtered off:</b><br/>Yield lower if warm / solubility higher if warm</p> <p><b>The crystals were compressed in the funnel:</b><br/>Air passes through the sample not just round it</p> <p><b>A little cold water was poured through the crystals:</b><br/>To wash away soluble impurities</p> | <p>1</p> <p>1</p> <p>1</p> <p>1</p> | <p>AO1b</p> <p>AO1b</p> <p>AO1b</p> <p>AO1b</p> | <p>Allow better drying but not water squeezed out</p>                                  |
| 09.3 | <p>Water</p> <p>Press the sample of crystals between filter papers</p>                                                                                                                                                                                                                                                                                                                                                                                                                            | <p>1</p> <p>1</p>                   | <p>AO3 1b</p> <p>AO3 2b</p>                     | <p>Do not allow unreacted reagents</p> <p>Allow give the sample time to dry in air</p> |
| 09.4 | <p><math>M_r</math> product = 135.0</p> <p>Expected mass = <math>5.05 \times \frac{135.0}{93.0} = 7.33 \text{ g}</math></p> <p>Percentage yield = <math>\frac{4.82}{7.33} \times 100 = 65.75 = 65.8(\%)</math></p>                                                                                                                                                                                                                                                                                | <p>1</p> <p>1</p> <p>1</p>          | <p>AO2h</p> <p>AO2h</p> <p>AO1b</p>             | <p>Answer must be given to this precision</p>                                          |

|      |                                                                                                                                                                                                                               |   |        |                                         |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------|-----------------------------------------|
| 09.5 |  <p>OR</p> $\text{C}_6\text{H}_5\text{NHCOCH}_3 + \text{NO}_2^+ \rightarrow \text{C}_6\text{H}_4(\text{NHCOCH}_3)\text{NO}_2 + \text{H}^+$ | 1 | AO2c   |                                         |
| 09.6 | Electrophilic substitution                                                                                                                                                                                                    | 1 | AO1a   |                                         |
| 09.7 | Hydrolysis                                                                                                                                                                                                                    | 1 | AO3 1a |                                         |
| 09.8 | Sn/HCl                                                                                                                                                                                                                        | 1 | AO1b   | Ignore acid concentration; allow Fe/HCl |

| Question | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark                                                                    | AO                                                                                                | Comments                                                                                                                                                                                                                                                                                                                                                                          |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10       | <p><b>IR</b></p> <p>M1 Absorption at <math>3360\text{ cm}^{-1}</math> shows OH alcohol present</p> <p><b>NMR</b></p> <p>M2 There are 4 peaks which indicates 4 different environments of hydrogen</p> <p>M3 The integration ratio = <math>1.6 : 0.4 : 1.2 : 2.4</math><br/>The simplest whole number ratio is <math>4 : 1 : 3 : 6</math></p> <p>M4 The singlet (integ 1) must be caused by H in OH alcohol</p> <p>M5 The singlet (integ 3) must be due to a <math>\text{CH}_3</math> group with no adjacent H</p> <p>M6 Quartet + triplet suggest <math>\text{CH}_2\text{CH}_3</math> group</p> <p>M7 Integration 4 and integration 6 indicates two equivalent <math>\text{CH}_2\text{CH}_3</math> groups</p> <p>M8</p> <div style="text-align: center;"> <math display="block">  \begin{array}{c}  \text{CH}_2\text{CH}_3 \\    \\  \text{H}_3\text{C} - \text{C} - \text{OH} \\    \\  \text{CH}_2\text{CH}_3  \end{array}  </math> </div> | <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> | <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1a</p> <p>AO3 1b</p> <p>AO3 1b</p> <p>AO3 1b</p> | <p>Extended response</p> <p>Deduction of correct structure without explanation scores maximum of 4 marks as this does not show a clear, coherent line of reasoning.</p> <p>Maximum of 6 marks if no structure given OR if coherent logic not displayed in the explanations of how two of OH, <math>\text{CH}_3</math> and <math>\text{CH}_2\text{CH}_3</math> are identified.</p> |

| Question | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Mark | AO                         | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11.1     | $\text{CH}_3\text{CH}_2\text{COCH}_3 + 2[\text{H}] \longrightarrow \text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1    | AO1b                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 11.2     | <div> <div>                     This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.                 </div> <div> <div>                         Level 3<br/>5–6 marks                     </div> <div>                         All stages are covered and the explanation of each stage is generally correct and virtually complete.<br/><br/>                         Answer is communicated coherently and shows a logical progression from stage 1 to stage 2 then stage 3.                     </div> </div> <div> <div>                         Level 2<br/>3–4 marks                     </div> <div>                         All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.<br/><br/>                         Answer is mainly coherent and shows progression from stage 1 to stage 3.                     </div> </div> <div> <div>                         Level 1<br/>1–2 marks                     </div> <div>                         Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, OR only one stage is covered but the explanation is generally correct and virtually complete.<br/><br/>                         Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.                     </div> </div> <div> <div>                         Level 0<br/>0 marks                     </div> <div>                         Insufficient correct chemistry to gain a mark.                     </div> </div> </div> | 6    | 1<br>AO1a<br><br>5<br>AO2a | <p><b>Indicative Chemistry content</b></p> <p><b>Stage 1:</b> Formation of product</p> <ul style="list-style-type: none"> <li>Nucleophilic attack</li> <li>Planar carbonyl group</li> <li><math>\text{H}^-</math> attacks from either side (stated or drawn)</li> </ul> <p><b>Stage 2:</b> Nature of product</p> <ul style="list-style-type: none"> <li>Product of step 1 shown</li> <li>This exists in two chiral forms (stated or drawn)</li> <li>Equal amounts of each enantiomer/racemic mixture formed</li> </ul> <p><b>Stage 3:</b> Optical activity</p> <ul style="list-style-type: none"> <li>Optical isomers/enantiomers rotate the plane of polarised light equally in opposite directions</li> <li>With a racemic/equal mixture the effects cancel</li> </ul> |

| Question | Marking guidance                                                                                                                                                        | Mark                       | AO                                  | Comments                                                               |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------|------------------------------------------------------------------------|
| 12.1     | HBr OR HCl OR H <sub>2</sub> SO <sub>4</sub>                                                                                                                            | 1                          | AO1b                                | Allow HI or HY                                                         |
| 12.2     | <p>Electrophilic addition</p>                                                                                                                                           | <p>1</p> <p>4</p>          | <p>AO1a</p> <p>AO2a</p>             | <p>Allow consequential marking on acid in 12.1 and allow use of HY</p> |
| 12.3     | <p>The major product exists as a pair of enantiomers</p> <p>The third isomer is 1-bromobutane (minor product)</p> <p>Because it is obtained via primary carbocation</p> | <p>1</p> <p>1</p> <p>1</p> | <p>AO2a</p> <p>AO2a</p> <p>AO2a</p> |                                                                        |