<table>
<thead>
<tr>
<th>Question</th>
<th>Marking guidance</th>
<th>Mark</th>
<th>AO</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.1</td>
<td>CH₃CH₂CH==C==CH₂CH₂OH</td>
<td>1</td>
<td>AO1a</td>
<td></td>
</tr>
<tr>
<td>01.2</td>
<td></td>
<td>1</td>
<td>AO2c</td>
<td></td>
</tr>
</tbody>
</table>
### Stage 1: consider the groups joined to right hand carbon of the C=C bond

- Consider the atomic number of the atoms attached
  - C has a higher atomic number than H, so CH₂OH takes priority

### Stage 2: consider the groups joined to LH carbon of the C=C bond

- Both groups contain C atoms, so consider atoms one bond further away
  - C, (H and H) from ethyl group has higher atomic number than H, (H and H) from methyl group, so ethyl takes priority

### Stage 3: conclusion

- The highest priority groups, ethyl and CH₂OH are on same side of the C=C bond so the isomer is Z
- The rest of the IUPAC name is 3-methylpent-2-en-1-ol

---

**Extended response**

Maximum of 5 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

M1 can be scored in stage 1 or stage 2

Allow M5 for correct ECF conclusion using either or both wrong priorities deduced in stages 1 and 2
| 01.4 | Moles of maleic acid = \(\frac{10.0}{116.0} = 8.62 \times 10^{-2}\)  
AND mass of organic product expected = \((8.62 \times 10^{-2}) \times 98.0\)  
= 8.45 g  
Or moles of organic product formed = \(\frac{6.53}{98.0} = 6.66 \times 10^{-2}\)  
% yield = \(100 \times \frac{6.53}{8.45}\)  
OR \(= 100 \times \frac{(6.66 \times 10^{-2})}{(8.62 \times 10^{-2})}\)  
= 77.294 = 77.3%  
AND statement that the student was NOT correct  |
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>AO3 1a</td>
</tr>
<tr>
<td>Question</td>
<td>Marking guidance</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>02.1</td>
<td>C₆H₁₁OH + ¹⁸O₂ → 6CO₂ + 6H₂O</td>
</tr>
</tbody>
</table>
| 02.2     | Temperature rise = 20.1  
q = 50.0 × 4.18 × 20.1 = 4201 (J)  
Mass of alcohol burned = 0.54 g and M, alcohol = 100.0  
∴ mol of alcohol = n = 0.54/100 = 0.0054  
Heat change per mole = q/1000n OR q/n  
= 778 kJ mol⁻¹ OR 778 000 J mol⁻¹  
ΔH = −778 kJ mol⁻¹ OR −778 000 J mol⁻¹ | 1    | AO2h | M₄ is for answer with negative sign for exothermic reaction  
Units are tied to the final answer and must match |
| 02.3     | Less negative than the reference  
Heat loss OR incomplete combustion OR evaporation of alcohol  
OR heat transferred to beaker not taken into account | 1    | AO3 1b |
| 02.4     | Water has a known density (of 1.0 g cm⁻³)  
Therefore, a volume of 50.0 cm³ could be measured out | 1    | AO3 2a |
### Question 03.1
(Compounds with the) same molecular formula but different structural / displayed / skeletal formula

- Marking guidance: 1 AO1a

### Question 03.2
(basic) elimination

- Mechanism points:
  - Correct arrow from lone pair on :OH\(^-\) to H on C adjacent to C–Br (1 AO2a)
  - Correct arrow from C–H bond to C–C (1 AO2a)
  - Correct arrow from C–Br bond to Br (1 AO2a)
  - Structure of chosen product (1 AO2a)

![Diagram of mechanisms](image)

**OR**

![Alternative diagram](image)
### Question 04.1

**Marking guidance**

Percentage of oxygen by mass = 100 – 40.9 – 4.5 = 54.6

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>H</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>40.9</td>
<td>4.5</td>
<td>54.6</td>
</tr>
</tbody>
</table>

Divide by $A_r$

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<tr>
<th></th>
<th>12</th>
<th>1</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.41</td>
<td>4.5</td>
<td>3.41</td>
</tr>
</tbody>
</table>

Divide by smallest

<table>
<thead>
<tr>
<th></th>
<th>3.41</th>
<th>4.5</th>
<th>3.41</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1.32</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3.41</td>
<td>3.41</td>
<td>3.41</td>
</tr>
</tbody>
</table>

Nearest whole number ratio = 1 × 3 : 1.32 × 3 : 1 × 3 = 3 : 3.96 : 3

Nearest integer ratio = 3 : 4 : 3

Empirical formula $C_3H_4O_3$

Empirical formula mass = 88 = molecular formula mass

Therefore, molecular formula is same as the empirical formula - $C_3H_4O_3$

**Mark** 1  
**AO** 1b

**Comments**

### Question 04.2

**Marking guidance**

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

**Mark** 1  
**AO** 1a
| 04.3 | Advantage – ethanol is produced at a faster rate  
Disadvantage – more energy is used / required in the reaction | 1 | AO2e |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>04.4</td>
<td>Air gets in / oxidation occurs</td>
<td>1</td>
<td>AO1a</td>
</tr>
</tbody>
</table>
| 04.5 | Alcohol OH absorption in different place (3230–3550 cm\(^{-1}\)) from acid OH absorption (2500–3000 cm\(^{-1}\))  
The C=O in acids has an absorption at 1680–1750 cm\(^{-1}\) | 1  | AO2e |
<table>
<thead>
<tr>
<th>Question</th>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>05.1</td>
<td>UV light</td>
<td>1</td>
<td>AO1a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\text{CCl}_4 \rightarrow \text{CCl}_3 \cdot + \cdot \text{Cl}$</td>
<td>1</td>
<td>AO2a</td>
<td></td>
</tr>
<tr>
<td>05.2</td>
<td>$\text{Cl} \cdot + \text{O}_3 \rightarrow \text{ClO} \cdot + \text{O}_2$</td>
<td>1</td>
<td>AO1a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\text{ClO} \cdot + \text{O}_3 \rightarrow \text{Cl} \cdot + 2\text{O}_2$</td>
<td>1</td>
<td>AO1a</td>
<td></td>
</tr>
<tr>
<td>05.3</td>
<td>$M_r \text{ of CF}_3\text{Cl} = 104.5$</td>
<td>1</td>
<td>AO1b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moles freon = $1.78 \times 10^{-4} \times 10^3 / 104.5 = 1.70 \times 10^{-3}$</td>
<td>1</td>
<td>AO1b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of molecules = $1.70 \times 10^{-3} \times 6.02 \times 10^{23} = 1.02 \times 10^{21}$</td>
<td>1</td>
<td>AO1b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Molecules in 500 cm$^3$ = $(1.02 \times 10^{21} \times 500 \times 10^{-6}) / 100 = 5.10 \times 10^{15}$</td>
<td>1</td>
<td>AO1b</td>
<td>Allow answer in the range $5.10–5.13 \times 10^{15}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Answer must be given to this precision</td>
</tr>
<tr>
<td>Question</td>
<td>Marking guidance</td>
<td>Mark</td>
<td>AO</td>
<td>Comments</td>
</tr>
<tr>
<td>----------</td>
<td>------------------</td>
<td>------</td>
<td>----</td>
<td>----------</td>
</tr>
<tr>
<td>06.1</td>
<td>Alkenes</td>
<td>1</td>
<td>AO1a</td>
<td>Correctly drawn molecule of cyclobutane or methyl cyclopropane, need not be displayed formula</td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="Molecule Diagram" /></td>
<td></td>
<td>AO2a</td>
<td>Allow hexane or any other correctly named alkane with 6 carbons</td>
</tr>
<tr>
<td>06.2</td>
<td>C₆H₁₄ (or correct alkane structure with 6 carbons)</td>
<td>1</td>
<td>AO2a</td>
<td>Allow hexane or any other correctly named alkane with 6 carbons</td>
</tr>
<tr>
<td>06.3</td>
<td>Poly(but-2-ene)</td>
<td>1</td>
<td>AO1a</td>
<td></td>
</tr>
</tbody>
</table>
| 06.4     | High pressure    | 1    | AO1b | Allow pressure ≥ 1 MPa  
Mention of catalyst loses the mark |
This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

<table>
<thead>
<tr>
<th>Level 3</th>
<th>5–6 marks</th>
<th>Indicative chemistry content</th>
</tr>
</thead>
<tbody>
<tr>
<td>All stages are covered and the explanation of each stage is generally correct and virtually complete. Answer communicates the whole process coherently and shows a logical progression from stage 1 and stage 2 (in either order) to stage 3.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 2</th>
<th>3–4 marks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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. Answer is mainly coherent and shows progression. Some steps in each stage may be out of order and incomplete.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 1</th>
<th>1–2 marks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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. Answer includes isolated statements but these are not presented in a logical order or show confused reasoning.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 0</th>
<th>0 marks</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Insufficient correct chemistry to gain a mark.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Marking guidance</td>
<td>Mark</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>07.1</td>
<td>Measured volume would be greater</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Level in burette falls as tap is filled before any liquid is delivered</td>
<td>1</td>
</tr>
<tr>
<td>07.2</td>
<td>Drop sizes vary</td>
<td>1</td>
</tr>
<tr>
<td>07.3</td>
<td>Use a larger single volume of oil</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Dissolve this oil in the organic solvent</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Transfer to a conical flask and make up to 250 cm³ with more solvent</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Titrate (25 cm³) samples from the flask</td>
<td>1</td>
</tr>
</tbody>
</table>
**Stage 1**

Mass of oil = 0.92 \times (5.0 \times 10^{-2} \times 5) = 0.23 \text{ (g)}

Mol of oil = \frac{0.23}{885} = 2.6 \times 10^{-4}

**Stage 2**

Mol bromine = 2.0 \times 10^{-2} \times 39.4 / 1000 = 7.9 \times 10^{-4}

**Stage 3**

Ratio oil : bromine

2.6 \times 10^{-4} : 7.9 \times 10^{-4}

Simplest ratio = \frac{2.6 \times 10^{-4}}{2.6 \times 10^{-4}} : \frac{7.9 \times 10^{-4}}{2.6 \times 10^{-4}}

= 1 : 3

Hence, 3 C=C bonds

<table>
<thead>
<tr>
<th>07.4</th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>Mass of oil = 0.92 \times (5.0 \times 10^{-2} \times 5) = 0.23 \text{ (g)}</td>
<td>Mol bromine = 2.0 \times 10^{-2} \times 39.4 / 1000 = 7.9 \times 10^{-4}</td>
<td>Ratio oil : bromine</td>
</tr>
<tr>
<td>0.3</td>
<td>Mol of oil = \frac{0.23}{885} = 2.6 \times 10^{-4}</td>
<td>2.6 \times 10^{-4} : 7.9 \times 10^{-4}</td>
<td>2.6 \times 10^{-4} : 7.9 \times 10^{-4}</td>
</tr>
<tr>
<td>0.3</td>
<td>Simplest ratio = 1 : 3</td>
<td>Simplest ratio = 1 : 3</td>
<td>1 : 3</td>
</tr>
<tr>
<td>0.3</td>
<td>Hence, 3 C=C bonds</td>
<td>1 AO2h</td>
<td>1 AO3 1a</td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td></td>
<td>M5 cannot be awarded unless working for M4 is shown</td>
</tr>
</tbody>
</table>

**Extended response calculation**

To gain 4 or 5 marks, students must show a logical progression from stage 1 and stage 2 (in either order) to stage 3
Section B

In this section, each correct answer is awarded 1 mark.

<table>
<thead>
<tr>
<th>Question</th>
<th>Key</th>
<th>AO</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>B</td>
<td>AO2b</td>
</tr>
<tr>
<td>9</td>
<td>C</td>
<td>AO1a</td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>AO2d</td>
</tr>
<tr>
<td>11</td>
<td>C</td>
<td>AO2a</td>
</tr>
<tr>
<td>12</td>
<td>D</td>
<td>AO1b</td>
</tr>
<tr>
<td>13</td>
<td>B</td>
<td>AO1a</td>
</tr>
<tr>
<td>14</td>
<td>C</td>
<td>AO1b</td>
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<tr>
<td>15</td>
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<td>D</td>
<td>AO1a</td>
</tr>
<tr>
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<tr>
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<td>AO1a</td>
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<tr>
<td>21</td>
<td>A</td>
<td>AO3 2b</td>
</tr>
<tr>
<td>22</td>
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<td>AO3 2b</td>
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