Alkanes

1. Predict the molecular formula of an alkane with 13 carbon atoms.

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[Total 1 mark]

2. The table below lists the boiling points of some alkanes.

<table>
<thead>
<tr>
<th>alkane</th>
<th>number of carbon atoms</th>
<th>molecular formula</th>
<th>boiling point °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>butane</td>
<td>4</td>
<td>C_4H_{10}</td>
<td>0</td>
</tr>
<tr>
<td>pentane</td>
<td>5</td>
<td>C_5H_{12}</td>
<td>36</td>
</tr>
<tr>
<td>hexane</td>
<td>6</td>
<td>C_6H_{14}</td>
<td>69</td>
</tr>
<tr>
<td>heptane</td>
<td>7</td>
<td>C_7H_{16}</td>
<td>99</td>
</tr>
<tr>
<td>octane</td>
<td>8</td>
<td>C_8H_{18}</td>
<td></td>
</tr>
<tr>
<td>nonane</td>
<td>9</td>
<td>C_9H_{20}</td>
<td>152</td>
</tr>
<tr>
<td>decane</td>
<td>10</td>
<td>C_{10}H_{22}</td>
<td>175</td>
</tr>
</tbody>
</table>

(i) Predict the boiling point of octane.

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[1]

(ii) State and explain the trend in the boiling points of these alkanes.

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[Total 3 marks]
3. The graph below shows the boiling points of some alkanes.

(a) Draw a smooth curve through the points on the graph and estimate the boiling points of

octane $C_8H_{18}$, ……………… hexadecane, $C_{16}H_{34}$ ………………

(b) State how decane, $C_{10}H_{22}$, can be separated from a mixture of the alkanes.

...........................................................................................................................................................................
(c) Isomerisation of hexane, \( \text{C}_6\text{H}_{14} \), produces a mixture of structural isomers, three of which are shown in the boxes below.

(i) Draw, using skeletal formulae, **two** other structural isomers of hexane.

<table>
<thead>
<tr>
<th>isomer A</th>
<th>isomer B</th>
<th>isomer C</th>
</tr>
</thead>
</table>

(ii) Name isomer B. .................................................................

(iii) Isomers A, B and C have different boiling points. In the boxes below, list the isomers A, B and C in order of their boiling points.

   lowest boiling point   highest boiling point

(iv) Explain the order given in (c) (iii).

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................................................................................................................
................................................................................................................

(d) Oxygen-containing compounds can be added to improve the efficiency and performance of fuels.

In Formula One racing cars, it is common practice to add oxygen-containing compounds, such as 2-methylpropan-2-ol, \((\text{CH}_3)_3\text{COH}\). The amount of oxygen-containing compounds added is strictly controlled by the Federation Internationale de l'Automobile, FIA.

(i) Calculate the percentage by mass of oxygen in \((\text{CH}_3)_3\text{COH}\). Give your answer to three significant figures.

   answer ....................

(ii) Write a balanced equation for the complete combustion of \((\text{CH}_3)_3\text{COH}\).

   [2]

[Total 16 marks]
4. The table below lists the boiling points of some alkanes.

<table>
<thead>
<tr>
<th>alkane</th>
<th>number of carbon atoms</th>
<th>molecular formula</th>
<th>boiling point / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>butane</td>
<td>4</td>
<td>C_{4}H_{10}</td>
<td>0</td>
</tr>
<tr>
<td>pentane</td>
<td>5</td>
<td>C_{5}H_{12}</td>
<td>36</td>
</tr>
<tr>
<td>hexane</td>
<td>6</td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>heptane</td>
<td>7</td>
<td>C_{7}H_{16}</td>
<td>99</td>
</tr>
<tr>
<td>octane</td>
<td>8</td>
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<td></td>
</tr>
<tr>
<td>nonane</td>
<td>9</td>
<td>C_{9}H_{20}</td>
<td>152</td>
</tr>
<tr>
<td>decane</td>
<td>10</td>
<td>C_{10}H_{22}</td>
<td>175</td>
</tr>
</tbody>
</table>

(a) What is the molecular formula of hexane? .......................................................... [1]

(b) (i) State the trend in the boiling points of the alkanes.

........................................................................................................................................ [1]

........................................................................................................................................

(ii) Explain the trend in the boiling points of the alkanes.

........................................................................................................................................ [1]

........................................................................................................................................

(iii) Predict the boiling point of octane. ............ °C

................................................................. [1]

[Total 4 marks]
5. Cyclohexane and cyclohexene are both cyclic hydrocarbons.

(i) What is the molecular formula of cyclohexene? ...............................................

(ii) What is the empirical formula of cyclohexene? ..............................................

(iii) Calculate the percentage, by mass, of carbon in cyclohexene. Give your answer
to two significant figures.

answer .............................................

[Total 4 marks]
6. (a) Heptane can be isomerised to produce branched chain alkanes such as 2-methylhexane or 2,3-dimethylpentane.

The equation below shows the isomerisation of heptane into 2-methylhexane.

\[ \text{C}_7\text{H}_{16} \rightarrow \text{C}_7\text{H}_{14} \]

(i) Using skeletal formulae, complete the balanced equation for the isomerisation of heptane into 2,3-dimethylpentane.

\[ \text{C}_7\text{H}_{16} \rightarrow \text{C}_9\text{H}_{20} \]

(ii) The boiling point of 2,3-dimethylpentane is 84 °C.

Predict the boiling point of 2-methylhexane. ................. °C

(b) Heptane can be reformed to produce methylcyclohexane which is a cycloalkane.

Write a balanced equation to show the reforming of heptane to obtain methylcyclohexane
7. There are several cycloalkanes that are structural isomers of C₅H₁₀.

(i) Complete the boxes by drawing two other structural isomers of C₅H₁₀ that are also cycloalkanes.

<table>
<thead>
<tr>
<th>Isomer L</th>
<th>ethylcyclopropane</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Structure 1" /></td>
<td><img src="image2.png" alt="Structure 2" /></td>
</tr>
</tbody>
</table>

(ii) Name isomer L drawn in (i).

..................................................................................................................................................

(iii) Draw the skeletal formula of isomer L.

[Total 4 marks]
8. (a) Many organic molecules show structural isomerism. State what is meant by the term *structural isomerism*.

..........................................................................................................................

..........................................................................................................................

[2]

(b) Isomers 1, 2 and 3, shown below, are unsaturated structural isomers of C₅H₁₀.

\[
\begin{array}{ccc}
\text{H} & \text{C} & \text{H} \\
\text{CH₃CH₂CH₂} & \text{C} & \text{H} \\
& \text{CH₃CH₂} & \text{CH₃} \\
\end{array}
\]

isomer 1

\[
\begin{array}{ccc}
\text{H} & \text{C} & \text{H} \\
\text{CH₃CH₂} & \text{C} & \text{H} \\
& \text{CH₃CH₂} & \text{H} \\
\end{array}
\]

isomer 2

\[
\begin{array}{ccc}
\text{H₃C} & \text{C} & \text{H} \\
\text{CH₃CH₂} & \text{C} & \text{H} \\
& \text{CH₃CH₂} & \text{H} \\
\end{array}
\]

isomer 3

(i) Complete the boxes by drawing two other unsaturated structural isomers of C₅H₁₀.

[2]

(ii) Name isomer 3.

..........................................................................................................................

[1]

(iii) Draw the skeletal formula of isomer 2.

[1]

[Total 6 marks]
Four possible structural isomers of $\text{C}_4\text{H}_{10}\text{O}$ are alcohols. Two are shown below.

<table>
<thead>
<tr>
<th>Structure 1</th>
<th>Structure 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Structure 1" /></td>
<td><img src="image2" alt="Structure 2" /></td>
</tr>
<tr>
<td><strong>butan-1-ol</strong></td>
<td><strong>butan-2-ol</strong></td>
</tr>
</tbody>
</table>

(i) Draw the other two structural isomers of $\text{C}_4\text{H}_{10}\text{O}$ that are alcohols

<table>
<thead>
<tr>
<th>Isomer 1</th>
<th>Isomer 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Isomer 1" /></td>
<td><img src="image4" alt="Isomer 2" /></td>
</tr>
</tbody>
</table>

(ii) Name isomer 1. .................................................................

[Total 3 marks]