5-7 Organic Chemistry – Trilogy

1.0 A student investigated the viscosity of liquid hydrocarbons.
   The student used this method:
   1. Measure 40 cm³ of the liquid hydrocarbon.
   2. Pour the liquid hydrocarbon into the funnel.

3. Time how long it takes for all of the liquid hydrocarbon to run out of the funnel.
4. Repeat the experiment for the other liquid hydrocarbons.

1.1 Give the name of apparatus A in Figure 1.

_____________________________________________________________________

[1 mark]

1.2 Name the apparatus that could be used to measure 40cm³ of liquid hydrocarbon.

_____________________________________________________________________

[1 mark]
The student’s results for six liquid hydrocarbons are shown in Table 1.

<table>
<thead>
<tr>
<th>Formula of liquid hydrocarbon</th>
<th>Time for liquid hydrocarbon to run out of the funnel in seconds</th>
<th>Mean time in seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₆H₁₄</td>
<td>12.2 11.8 12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>C₇H₁₆</td>
<td>14.7 15.2 15.4</td>
<td>15.1</td>
</tr>
<tr>
<td>C₈H₁₈</td>
<td>18.7 19.9 18.9</td>
<td></td>
</tr>
<tr>
<td>C₁₀H₂₂</td>
<td>27.6 26.8 28.2</td>
<td>27.5</td>
</tr>
<tr>
<td>C₁₂H₂₆</td>
<td>48.3 48.5 48.1</td>
<td>47.4</td>
</tr>
<tr>
<td>C₁₄H₃₀</td>
<td>65.9 67.1 69.0</td>
<td>67.3</td>
</tr>
</tbody>
</table>

1.3 Explain how the data show that the student’s results are precise.  

_____________________________________________________________________

_____________________________________________________________________

1.4 Describe the pattern shown on Table 1 between the number of carbon atoms in a molecule of liquid hydrocarbon and the time taken for the liquid hydrocarbon to run out of the funnel.  

_____________________________________________________________________

_____________________________________________________________________

1.5 Identify the anomalous result on the table.  
Suggest one error the student may have made to get this anomalous result.  

Anomalous result: ____________  
Error: ______________________
1.6 Use the data in Table 1 to calculate the mean time in seconds for C₈H₁₈.
Give your answer to an appropriate number of significant figures.

[1 mark]

Mean time = ___________ s

1.7 Give one safety precaution the student should take when carrying out this experiment.

[1 mark]

_____________________________________________________________________
_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________
2.0 This question is about organic molecules.

2.1 Large hydrocarbon molecules can be broken into smaller molecules by heating with a catalyst.

The equation shows one example of this type of reaction.

\[ C_{11}H_{24} \rightarrow 2C_3H_6 + C_5H_{12} \]

Which word describes this type of reaction?

Tick one box.

- Cracking
- Polymerisation
- Precipitation
- Reduction

[1 mark]

2.2 Figure 2 shows propene as a displayed structure.

Figure 2

\[ \text{H} \quad \text{C} \quad \text{C} = \text{C} \quad \text{H} \\
\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \]

Draw a ring around the part of the molecule which makes propene unsaturated.

[1 mark]

2.3 Bromine water changes colour when mixed with an unsaturated compound like propene.

Complete the sentences.

Use words from the box.

[2 marks]

<table>
<thead>
<tr>
<th>Blue</th>
<th>Colourless</th>
<th>Green</th>
<th>Orange</th>
<th>Red</th>
</tr>
</thead>
</table>

Before mixing with propene, bromine water is _________________.

After mixing with propene, bromine water is _________________.

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3.1 Which one of the following is not an alkane?

Tick one box.

- C₈H₁₅
- C₁₂H₂₆
- C₁₆H₃₄
- C₂₄H₅₀

3.2 Which has the highest boiling point?

Draw a ring around the correct answer.

- C₃H₆
- C₅H₁₂
- C₁₀H₂₂
- C₈H₁₈

3.3 Table 2 shows some information about alkanes.

Table 2

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Relative formula mass</th>
<th>Boiling point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>methane</td>
<td>CH₄</td>
<td>16</td>
<td>−160</td>
</tr>
<tr>
<td>ethane</td>
<td>C₂H₆</td>
<td>30</td>
<td>−90</td>
</tr>
<tr>
<td>propane</td>
<td>C₃H₈</td>
<td>44</td>
<td>−40</td>
</tr>
<tr>
<td>butane</td>
<td>C₄H₁₀</td>
<td>58</td>
<td>−1</td>
</tr>
<tr>
<td>pentane</td>
<td>C₅H₁₂</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>hexane</td>
<td>C₆H₁₄</td>
<td>86</td>
<td>68</td>
</tr>
</tbody>
</table>

What is the formula of heptane, the next member of the series?

[1 mark]
3.4 Draw a graph of relative formula mass against boiling point.
On the graph:
• plot the points
• draw a line of best fit.

3.5 Give two conclusions you can make from your graph.
4.0 Crude oil contains a mixture of hydrocarbons.

The table below shows the relative market demand and available supply of each fraction.

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Boiling point in °C</th>
<th>Relative % supply in crude oil</th>
<th>Relative % demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Petroleum Gas</td>
<td>Less than 30</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Gasoline (petrol)</td>
<td>30-160</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Kerosene (paraffin)</td>
<td>160-250</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Diesel</td>
<td>220-350</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Fuel and Heavy oils</td>
<td>Greater than 350</td>
<td>53</td>
<td>20</td>
</tr>
</tbody>
</table>

4.1 Describe how fractional distillation and cracking are used so that sufficient petrol is produced from crude oil to meet demand.

Use the information in the table, and your own knowledge. [6 marks]

_____________________________________________________________________
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## MARK SCHEME

<table>
<thead>
<tr>
<th>Qu No.</th>
<th>Extra Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>(conical) flask</td>
</tr>
<tr>
<td>1.2</td>
<td>measuring cylinder / pipette / burette</td>
</tr>
<tr>
<td>1.3</td>
<td>Little difference from mean between the repeats / little spread about the mean</td>
</tr>
<tr>
<td>1.4</td>
<td>As the number of carbon atoms increases, the time taken for the hydrocarbon to run out of the funnel increases</td>
</tr>
<tr>
<td>1.5</td>
<td>C\textsubscript{8}H\textsubscript{18} Trial 2 Any one from:</td>
</tr>
<tr>
<td></td>
<td>• longer hydrocarbon used</td>
</tr>
<tr>
<td></td>
<td>• volume of hydrocarbon too great</td>
</tr>
<tr>
<td></td>
<td>• started timing early</td>
</tr>
<tr>
<td></td>
<td>• stopped timing too late</td>
</tr>
</tbody>
</table>
| 1.6    | \[
\frac{18.7 + 18.9}{2} = 18.8 \]

<table>
<thead>
<tr>
<th>Extra Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow 19.9; or this result circled on table must indicate why the result is higher than the others.</td>
</tr>
<tr>
<td>allow the temperature was lower or the students used a thinner funnel.</td>
</tr>
<tr>
<td>1.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qu No.</th>
<th>Extra Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Cracking</td>
</tr>
<tr>
<td>2.2</td>
<td>Ring drawn around the functional group Minimum to enclose C=C Must not enclose any of the atoms of the methyl group</td>
</tr>
<tr>
<td>2.3</td>
<td>Orange Colourless</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Qu No.</th>
<th>Extra Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>C\textsubscript{6}H\textsubscript{15}</td>
</tr>
<tr>
<td>3.2</td>
<td>C\textsubscript{10}H\textsubscript{22}</td>
</tr>
<tr>
<td>3.3</td>
<td>C\textsubscript{7}H\textsubscript{16}</td>
</tr>
<tr>
<td>3.4</td>
<td>All points plotted correctly Best fit straight line ± ½ small square Allow 1 mark for 5/6 plotted correctly</td>
</tr>
<tr>
<td>3.5</td>
<td>As the relative formula mass increases the higher the temperature of the boiling point non-linear/not proportional or change gets smaller as relative formula mass gets higher</td>
</tr>
</tbody>
</table>
Qu No. | Extra Information | Marks  
--- | --- | ---  
4.1 | A detailed and coherent description is given for both processes, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. | 5-6  
**Level 3:** |  
**Level 2:** | A description is given which demonstrates a reasonable understanding of the key scientific ideas. Links are made but may not be fully articulated and/or precise. | 3-4  
**Level 1:** | Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised. | 1-2  
No relevant content | 0  

**Indicative content**

**Fractional distillation**
- Crude oil heated / evaporated
- Vapours enter column
- Vapours condense and are collected at different levels
- Each fraction has different boiling / condensing point
- Each fraction has different size molecules

**Cracking**
- Large molecules heated / evaporated / vaporised
- Molecules cracked / broken/ decomposed
- Passed over hot catalyst at ~450-550°C or
- Heated with water/steam at ~800-900°C
- Smaller molecules are produced
- Products contain alkenes and alkanes
- Alkenes used for making polymers or alcohols
- Alkanes used for fuels