1) The diagram shows a fractionating tower used to separate crude oil.

a) Explain how crude oil is separated into its constituent fractions.

Use the words in the box in your answer.

**Answer:** Heat energy is used to boil the crude oil and turn it into a vapour. The molecules enter the fractionating tower. Molecules are 'sorted out' according to their boiling point – this decreases on going up the column. Molecules with a smaller molecular size move to the top of the column (where it is cooler). Molecules with a larger molecular size move to the bottom of the column (where it is hotter). The vapour condenses to form a liquid. Each fraction is then collected over a small boiling point range.

b) Crude oil is a finite energy resource.

What does ‘finite resource’ mean?

**Answer:** Non-renewable resources that will run out.
c) **Products from crude oil are of crucial importance to us, and our lives would be very different without these.**

State two important products made from crude oil that are not mentioned in the above diagram.

**Answers:** Solvents, lubricants, polymers, detergents.

2) **Crude oil is a complicated mixture of hydrocarbons, many of which are alkanes.**

The boiling points of the first six members of the alkane homologous series are shown in the table below.

<table>
<thead>
<tr>
<th>Number of carbon atoms in alkane</th>
<th>Boiling point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>−162</td>
</tr>
<tr>
<td>2</td>
<td>−89</td>
</tr>
<tr>
<td>3</td>
<td>−42</td>
</tr>
<tr>
<td>4</td>
<td>−0.5</td>
</tr>
<tr>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td>6</td>
<td>69</td>
</tr>
</tbody>
</table>

a) **Plot the number of carbon atoms on the horizontal axis and the boiling point on the vertical axis on the graph below.**

![Graph showing the boiling points of alkanes vs. number of carbon atoms.](image)
b) Draw a best fit line through these points.

\[ \text{Answer: See graph.} \]

c) Use your graph to describe how the boiling point changes from two carbon atoms to six carbon atoms.

\[ \text{Answer: Almost linearly.} \]

d) Use your graph to determine the boiling point of the alkane with seven carbon atoms.

\[ \text{Answer: c.a. 100 °C.} \]

e) Which of the hydrocarbons are gases at room temperature, 20 °C?

\[ \text{Answer: The first four members are gases.} \]

3) A sample of petrol (gasoline) was analysed by a chemist.

She recorded a mass of petrol of 5.20 g.

The analysis found a substance called decane in the petrol.

The percentage of decane in the petrol sample was 4.8%, by mass.

Decane is an alkane containing ten carbon atoms in its molecule.

a) Which two elements are present in alkanes?

\[ \text{Answer: Hydrogen and carbon.} \]

b) What is the general formula for an alkane?

\[ \text{Answer: } C_nH_{(2n+2)} \]

c) Use your answer to part b) to work out the molecular formula for decane.

\[ \text{Answer: } C_{10}H_{22} \]
d) Complete the structure to show a decane molecule.

```
H - C - C - C - C - C - C - C - C - C - H
H     H     H     H     H     H     H     H     H
```

e) Explain why a decane molecule is described as ‘saturated’.

**Answer:** It contains carbon single bonds only.

f) Calculate the mass of decane in the petrol sample.

Give your answer to 3 significant figures.

Show your working.

**Answer:** The mass of decane = \( \frac{4.8}{100} \times 5.2 = 0.2496 \text{ g} \).

And to 3 significant figures, this would be 0.250 g.