In context

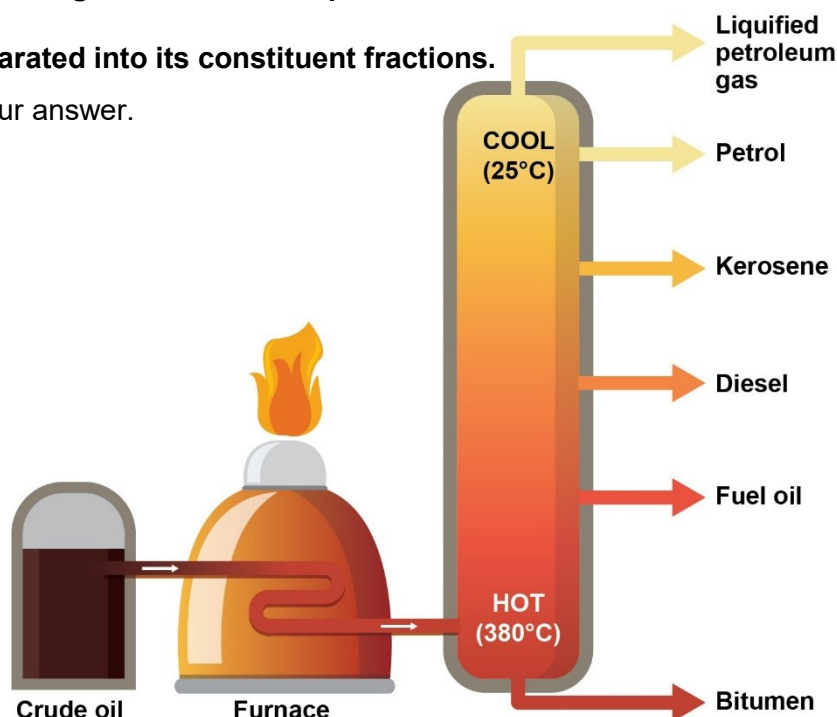| Subject area: Organic chemistry	Level: 14–16 years (Foundation)
Topic: Crude oil	Source: rsc.li/311PrTF

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.

Heat energy

Boil

Vapour

Condense

Boiling point

Molecular size

Source: Royal Society of Chemistry

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.

Number of carbon atoms in alkane	Boiling point in °C
1	−162
2	−89
3	−42
4	−0.5
5	36
6	69

a) **Plot the number of carbon atoms on the horizontal axis and the boiling point on the vertical axis on the graph below.**
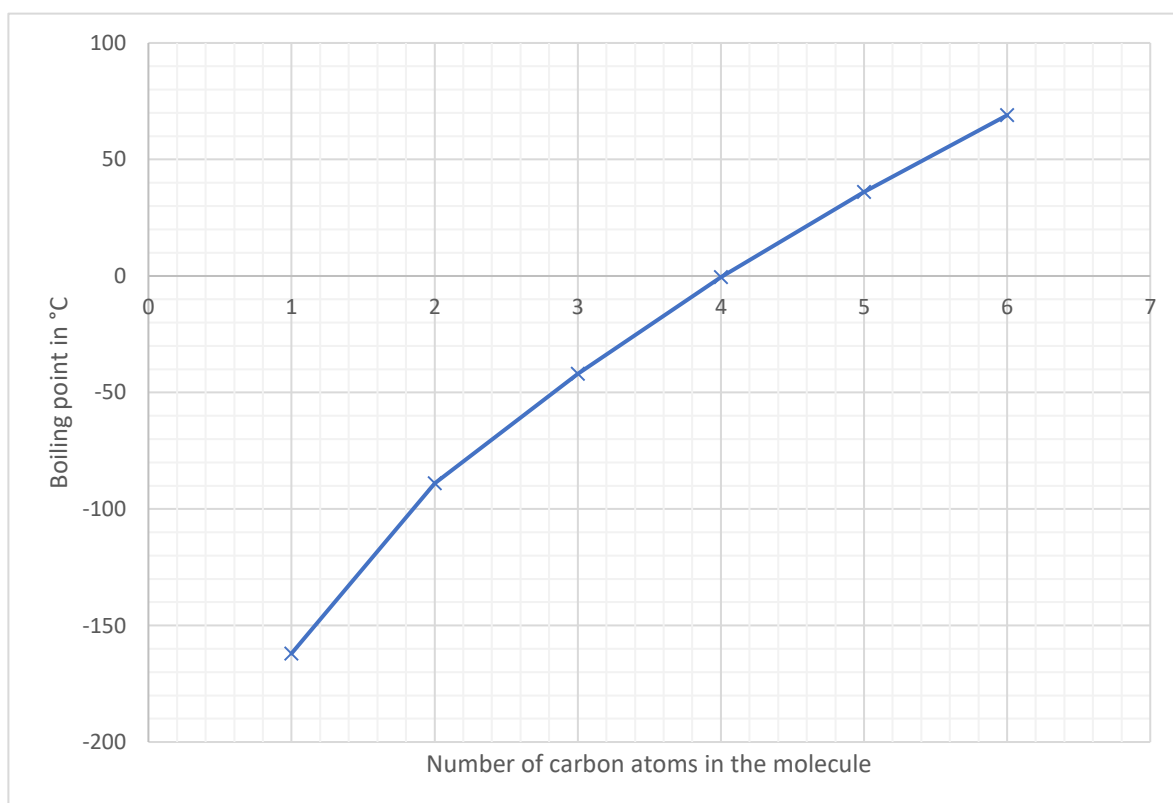
b) Draw a best fit line through these points.

Answer: See graph.

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

Answer: Almost linearly.

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

Answer: c.a. 100 °C.

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

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.

Source: Envato Elements

a) Which two elements are present in alkanes?
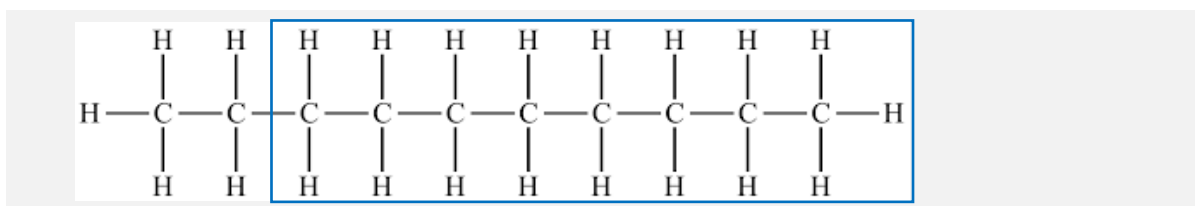
Answer: Hydrogen and carbon.

b) What is the general formula for an alkane?

Answer: $C_nH_{(2n+2)}$

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

Answer: $C_{10}H_{22}$

d) **Complete the structure to show a decane molecule.**

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 = $\frac{4.8}{100}$ × 5.2 = 0.2496 g.
   And to 3 significant figures, this would be 0.250 g.