

## AQA Chemistry Unit 9

### Crude Oil and Fuels

Crompton House  
□□□

Chemistry

|   |   | Learned<br>it | Revised<br>it |
|---|---|---------------|---------------|
| 1 | I can describe crude oil as a mixture of hydrocarbons               |               |               |
| 2 | I can name the first four alkanes                                   |               |               |
| 3 | I can relate the formula ( $C_nH_{2n+2}$ ) to alkane structure      |               |               |
| 4 | I can explain the process of fractional distillation                |               |               |
| 5 | I can explain the process of cracking and the production of alkenes |               |               |
| 6 | I can write balanced equations for the process of cracking          |               |               |

## **DODDLE QUIZZES**

AQA Crude Oil: \_\_\_\_\_%

AQA Hydrocarbons: \_\_\_\_\_%

AQA Combustion: \_\_\_\_\_%

## **Kerboodle Extension Quizzes**

Positive Points/postcards for completion

C9 Progress Quiz: Crude oil and fuels 1 \_\_\_\_\_%

C9 Progress Quiz: Crude oil and fuels 2 \_\_\_\_\_%

C9 Checkpoint quiz: Crude oil and fuels \_\_\_\_\_%

Self-Reflection

WWW:

EBI:

Checked by Teacher:

Date:

# Chapter 9: Crude oils and fuels

## Knowledge organiser

### Crude oil

**Crude oil** is incredibly important to our society and economy. It is formed from the remains of ancient biomass – living organisms (mostly plankton) that died many millions of years ago.

Raw crude oil is a thick black liquid made of a large number of different compounds mixed together. Most of the compounds are **hydrocarbons** of various sizes. Hydrocarbons are molecules made of carbon and hydrogen only.

### Combustion

Hydrocarbons are used as **fuels**. This is because when they react with oxygen they release a lot of energy. This reaction is called **combustion**. Complete combustion is a type of combustion where the only products are carbon dioxide and water.

### Properties

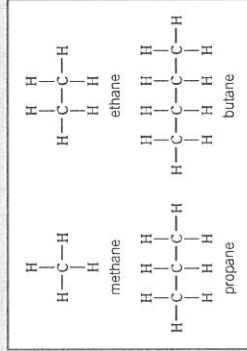
Whether or not a particular hydrocarbon is useful as a fuel depends on its properties:

- **flammability** – how easily it burns
  - **boiling point** – the temperature at which it boils
  - **viscosity** – how thick it is
- Its properties in turn depend on the length of the molecule.

| Chain length | Flammability | Boiling point | Viscosity         |
|--------------|--------------|---------------|-------------------|
| long chain   | low          | high          | high (very thick) |
| short chain  | high         | low           | low (very runny)  |

### Alkanes

One family of hydrocarbon molecules are called **alkanes**. Alkane molecules only have single bonds in them. The first four alkanes are:



The different alkanes have different numbers of carbon atoms and hydrogen atoms. You can always work the molecular formula of an alkane by using  $C_nH_{2n+2}$ .

### Key terms

Make sure you can write a definition for these key terms.

|              |         |                         |            |             |           |           |
|--------------|---------|-------------------------|------------|-------------|-----------|-----------|
| alkanes      | alkenes | boiling point           | combustion | cracking    | crude oil | feedstock |
| flammability |         | fractional distillation | fuel       | hydrocarbon | viscosity |           |

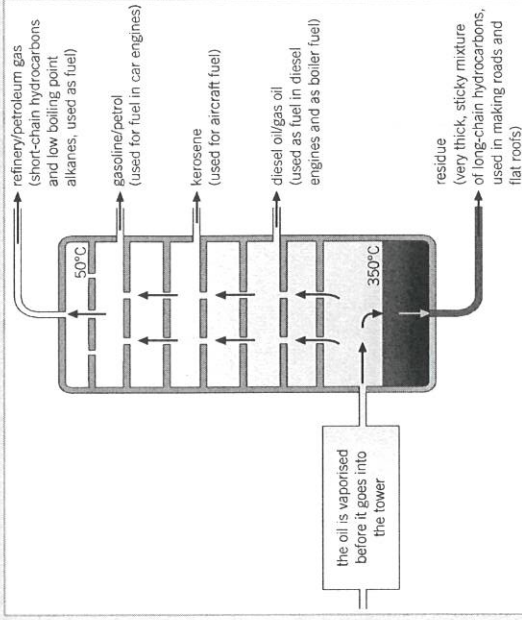
### Fractional distillation

The different hydrocarbons in crude oil are separated into fractions based on their boiling points in a process called **fractional distillation**. All the molecules in a fraction have a similar number of carbon atoms, and so a similar boiling point.

The process takes place in a fractionating column, which is hot at the bottom and cooler at the top.

The process works like this:

- 1 crude oil is vapourised (turned into a gas by heating)
- 2 the hydrocarbon gases enter the column
- 3 the hydrocarbon gases rise up the column
- 4 as hydrocarbon gases rise up the column they cool down
- 5 when the different hydrocarbons reach their boiling point in the column they condense
- 6 the hydrocarbon fraction is collected.



### Products from fractional distillation

Many useful products come from the separation of crude oil by fractional distillation.

| Fuels   | Feedstock  | Useful materials produced                      |
|---|--|--|
| petrol, diesel oil, kerosene, heavy fuel oil, and liquefied petroleum gases | fractions form the raw material for other processes and the production of other substances | solvents, lubricants, polymers, and detergents |

### Cracking

Not all hydrocarbons are as useful as each other. Longer molecules tend to be less useful than shorter ones. As such, there is a higher demand for shorter-chain hydrocarbons than longer-chain hydrocarbons.

A process called **cracking** is used to break up longer hydrocarbons and turn them into shorter ones.

Cracking produces shorter alkanes and **alkenes**.

Two methods of cracking are:

- catalytic cracking – vaporise the hydrocarbons, then pass them over a hot catalyst
- steam cracking – mix the hydrocarbons with steam at a very high temperature

### Alkenes

Alkenes are a family of hydrocarbons that contain double bonds between carbon atoms.

Alkenes are also used as fuels, and to produce polymers and many other materials.

They are much more reactive than alkanes. When mixed with bromine water, the bromine water turns from orange to colourless. This can be used to tell the difference between alkanes and alkenes.





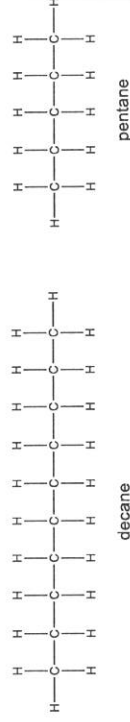
## FRACTIONAL DISTILLATION OF CRUDE OIL

|   |  |                  |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
|---|--|------------------|--------------------|------------------|----------------|--|---|--------------|--|---|----------------------|--|---|-----------|--|---|
| What is crude oil?  |  |                  |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| How is it separated? How does this work?                            | <p><b>FUEL GASES</b><br/>C<sub>1</sub>-C<sub>4</sub><br/>Color gas, LPG</p> <p><b>GASOLINE</b><br/>C<sub>5</sub>-C<sub>12</sub><br/>petrol for cars</p> <p><b>NAPHTHA</b><br/>C<sub>13</sub>-C<sub>16</sub><br/>petrochemicals</p> <p><b>KEROSENE</b><br/>C<sub>17</sub>-C<sub>24</sub><br/>jet fuel</p> <p><b>DIESEL (GAS OIL)</b><br/>C<sub>25</sub>-C<sub>36</sub><br/>fuel for diesel engines</p> <p><b>RESIDUE</b><br/>&gt; C<sub>37</sub><br/>distilled further at lower temperatures to produce LUBRICATING OIL, WAXES and BITUMEN</p> <p>unrefined crude oil</p> |                  |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| Are the fractions pure substances or mixtures?<br>How can you tell? |  |                  |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| How does the size of the hydrocarbons affect its properties         | <table><tr><td></td><td>Small hydrocarbons</td><td>Big hydrocarbons</td></tr><tr><td>Boiling points</td><td></td><td>↑</td></tr><tr><td>Flammability</td><td></td><td>↑</td></tr><tr><td>Cleanliness of flame</td><td></td><td>↑</td></tr><tr><td>Viscosity</td><td></td><td>↑</td></tr></table>   |                  | Small hydrocarbons | Big hydrocarbons | Boiling points |  | ↑ | Flammability |  | ↑ | Cleanliness of flame |  | ↑ | Viscosity |  | ↑ |
|   | Small hydrocarbons   | Big hydrocarbons |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| Boiling points  |  | ↑                |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| Flammability  |  | ↑                |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| Cleanliness of flame  |  | ↑                |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |
| Viscosity   |  | ↑                |                    |                  |                |  |   |              |  |   |                      |  |   |           |  |   |

1) Crude oil is a mixture of hydrocarbons. What are hydrocarbons.

2) The hydrocarbons in crude oil have different properties. Which of these properties does separation by fractional distillation depend on?

3) Two of the hydrocarbons in crude oil are decane and pentane.



Which of these molecules

a) has the higher boiling point?

b) is more runny?

c) catches fire more easily?

d) burns with the smokier flame?

e) collects higher up the fractionating column?

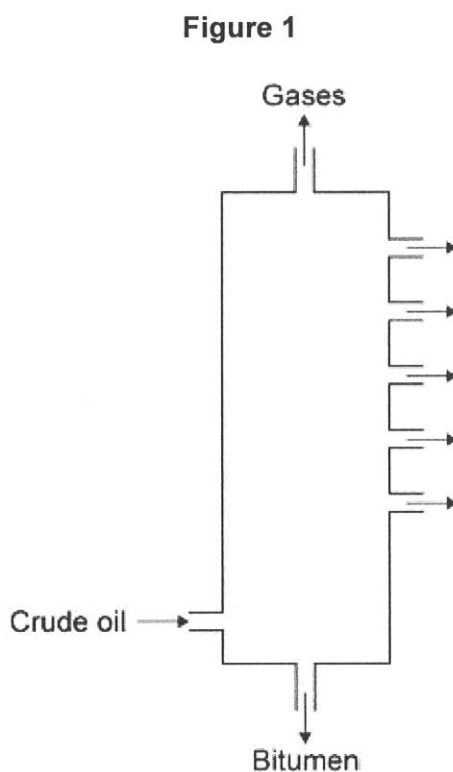
4) Kerosene is a fraction of crude oil used as fuel for aeroplanes. Is kerosene a pure substance or a mixture? Explain your answer.

## EXAM QUESTIONS

**Q1.** Crude oil is a mixture of hydrocarbons.

- (a) The hydrocarbons in crude oil are separated into fractions by fractional distillation.

**Figure 1** shows a fractional distillation column.



Crude oil vapour passes up the column.

Complete the sentence.

Choose the answer from the box.

|                  |                  |                |              |
|------------------|------------------|----------------|--------------|
| <b>condenses</b> | <b>dissolves</b> | <b>freezes</b> | <b>melts</b> |
|------------------|------------------|----------------|--------------|

Each fraction \_\_\_\_\_ at a different level.

(1)

(b) Why do the fractions separate?

Tick **one** box.

The fractions have different boiling points.

☐

The fractions have different flammability.

☐

The fractions have different melting points.

☐

The fractions have different viscosity.

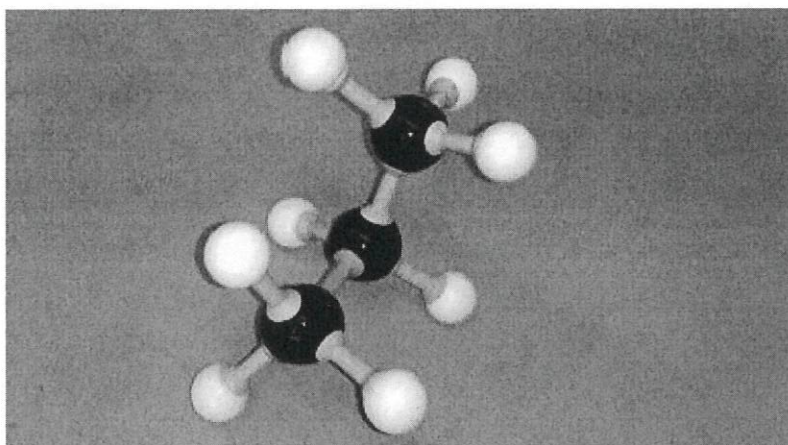
☐

(1)

Most of the hydrocarbons in crude oil are alkanes.

(c) **Figure 2** represents an alkane molecule.

**Figure 2**



Name the alkane.

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(1)

- (d) Methane (CH<sub>4</sub>) is an alkane.

What is the general formula for alkanes?

Tick **one** box.

C<sub>n</sub>H<sub>n</sub>

☐

C<sub>n</sub>H<sub>2n</sub>

☐

C<sub>n</sub>H<sub>2n-2</sub>

☐

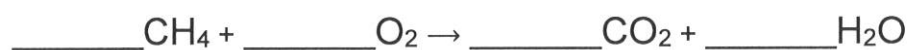
C<sub>n</sub>H<sub>2n+2</sub>

☐

(1)

- (e) Alkanes burn in oxygen.

Balance the equation for methane burning.



(1)

- (f) Ethene is an alkene.

Which reagent is used to test for alkenes?

Tick **one** box.

Anhydrous copper sulfate

☐

Bromine water

☐

Damp litmus paper

☐

Limewater

☐

(1)

**Q2.**

Crude oil is a resource found in rocks.

Most of the compounds in crude oil are hydrocarbons.

- (a) Complete the sentence.

Crude oil is formed by the decomposition of \_\_\_\_\_.

(1)

- (b) Alkanes are hydrocarbons.

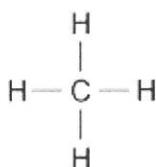
Give the name of the alkane molecule that has three carbon atoms.

\_\_\_\_\_

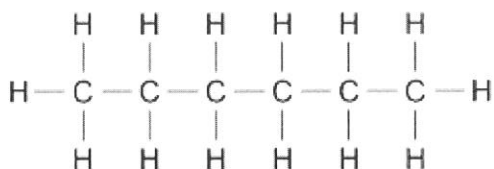
(1)

- (c) The figure below shows two alkane molecules.

**Methane**



**Hexane**



The table below shows the melting points and boiling points of methane and hexane.

|                | Melting point in<br>°C | Boiling point in<br>°C |
|----------------|------------------------|------------------------|
| <b>Methane</b> | -183                   | -162                   |
| <b>Hexane</b>  | -95                    | 69                     |

Compare the structure and properties of methane and hexane.

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(6)

Hydrocarbons are cracked to produce more useful alkanes and alkenes.

- (d) Decane ( $C_{10}H_{22}$ ) is cracked to produce **two** products.

Complete the equation for the reaction.



(1)

- (e)  $C_2H_4$  is an alkene.

What is the test for alkenes?

Give the result of the test if an alkene is present.

Test \_\_\_\_\_

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Result \_\_\_\_\_

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(2)

(Total 11 marks)

**Q3.** This question is about oil reserves.

- (a) Diesel is separated from crude oil by fractional distillation.

Describe the steps involved in the fractional distillation of crude oil.

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(3)

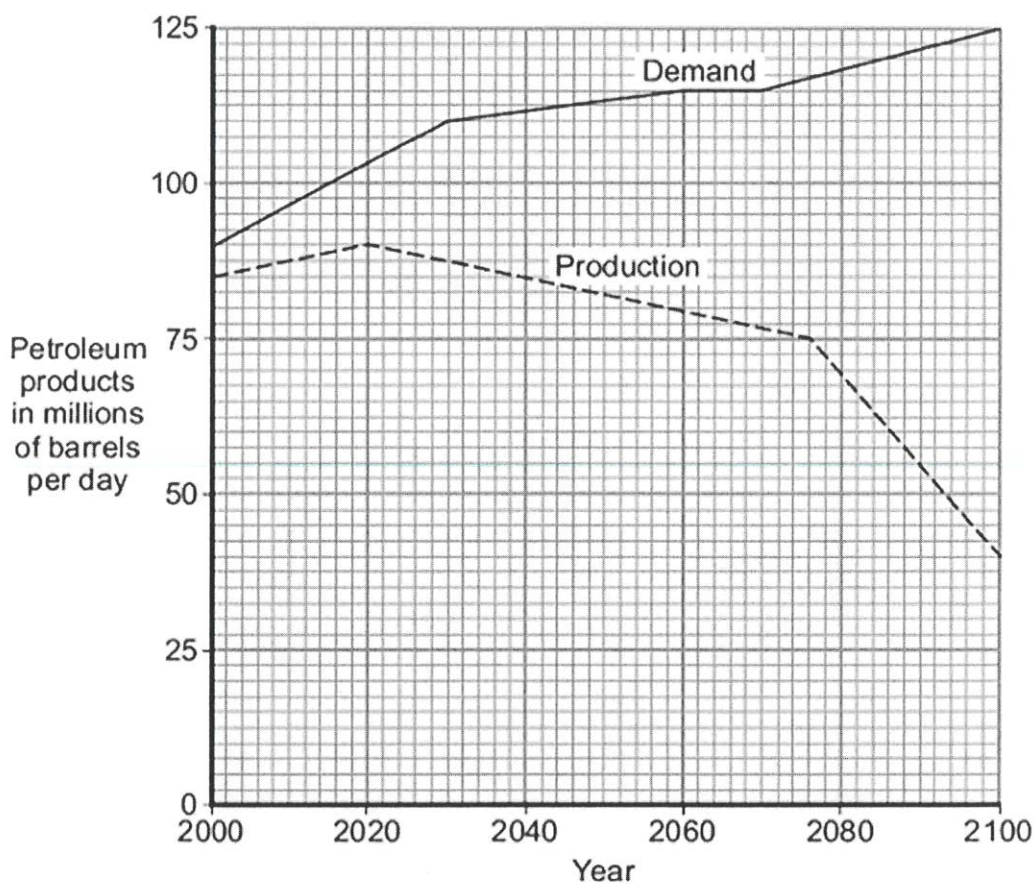
- (b) Diesel is a mixture of lots of different *alkanes*.

What are *alkanes*?

(2)

- (c) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Petroleum products, such as petrol, are produced from crude oil.  
The graph shows the possible future production of petroleum products from crude oil and the expected demand for petroleum products.



Canada's oil sands hold about 20% of the world's known crude oil reserves.

The oil sands contain between 10 to 15% of crude oil. This crude oil is mainly bitumen.

In Canada the oil sands are found in the ground underneath a very large area of forest. The trees are removed. Then large diggers and trucks remove 30 metres depth of soil and rock to reach the oil sands. The oil sands are quarried. Boiling water is mixed with the quarried oil sands to separate the bitumen from the sand. Methane (natural gas) is burned to heat the water.

The mixture can be separated because bitumen floats on water and the sand sinks to the bottom of the water. The bitumen is cracked and the products are separated by fractional distillation.

Use the information given and your knowledge and understanding to suggest the advantages and disadvantages of extracting petroleum products from oil sands.

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(6)  
(Total 11 marks)