

4.1 Fuels from crude oil

Key points

- Crude oil is a mixture of many different compounds.
- Distillation can be used to separate mixtures of liquids.
- Most of the compounds in crude oil are hydrocarbons – they contain only hydrogen and carbon.
- Alkanes are saturated hydrocarbons. They contain as many hydrogen atoms as possible in their molecules.

AQA Examiner's tip

Remember that the boiling point of a substance is the temperature at which its liquid boils when it is heated. When its gas is cooled it condenses at the same temperature.



An oil refinery at night

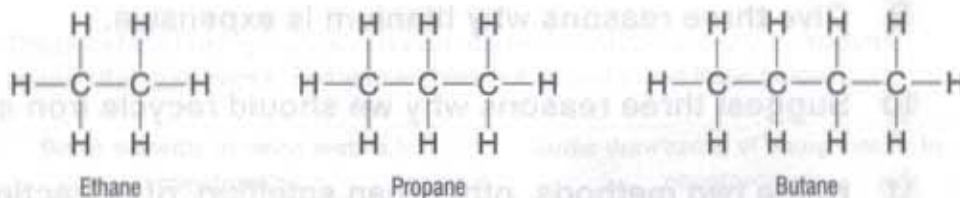
- Crude oil contains many different compounds that boil at different temperatures. These burn under different conditions and so crude oil needs to be separated to make useful fuels.
- We can separate a **mixture** of liquids by **distillation**. Simple distillation of crude oil can produce liquids that boil within different temperature ranges. These liquids are called **fractions**.

1 What are fractions?

- Most of the compounds in crude oil are **hydrocarbons**. This means that their molecules contain only hydrogen and carbon. Many of these hydrocarbons are **alkanes**, with the general formula C_nH_{2n+2} . Alkanes contain as many hydrogen atoms as possible in each molecule and so we call them **saturated hydrocarbons**.

2 How can you tell that the substance with the formula C_5H_{12} is an alkane?

- We can represent molecules in different ways. A molecular formula shows the number of each type of atom in each molecule, e.g. C_2H_6 represents a molecule of ethane. We can also represent molecules by a **displayed formula** that shows how the atoms are bonded together.



We can represent alkanes like this, showing all of the atoms and the covalent bonds in each molecule

3 What is the molecular formula of butane?

Key words: mixture, distillation, fraction, hydrocarbon, alkane, saturated hydrocarbon

4.2 Fractional distillation

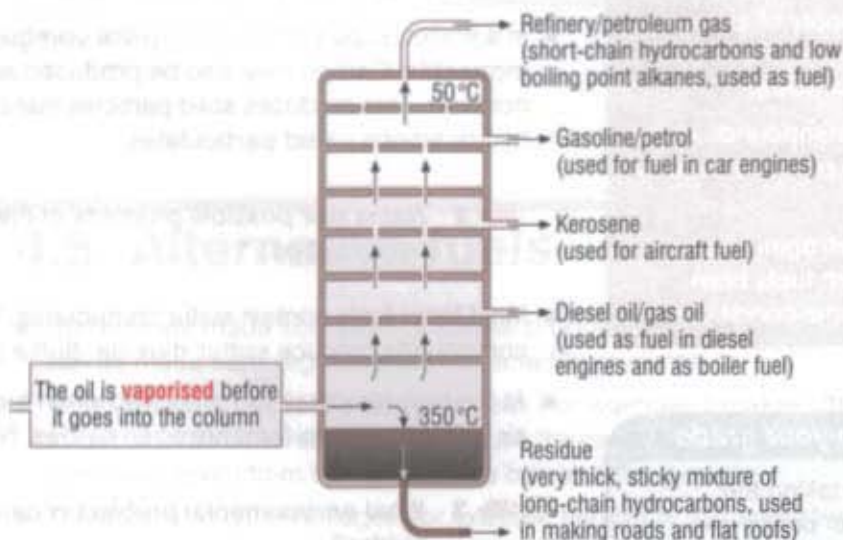
Key points

- Crude oil is separated into fractions using fractional distillation.
- The properties of each fraction depend on the size of the hydrocarbon molecules.
- Fractions with lower boiling points are less viscous and burn more easily.

AQA Examiner's tip

Simple distillation is done in steps by heating the mixture to different temperatures. Fractional distillation is done continuously by vaporising the mixture and condensing the fractions at different temperatures.

- Crude oil is separated into fractions at refineries using **fractional distillation**. This can be done because the boiling point of a hydrocarbon depends on the size of its molecule. The larger the molecule, the higher the boiling point of the hydrocarbon.
- The crude oil is vaporised and fed into a fractionating column. This is a tall tower that is hot at the bottom and gets cooler going up the column.



We use fractional distillation to separate crude oil into fractions. Each fraction contains compounds with similar boiling points.

- Inside the column there are many trays with holes to allow gases through. The vapours move up the column getting cooler as they go up. The hydrocarbons condense to liquids when they reach the level that is at their boiling point. Different liquids collect on the trays at different levels and there are outlets to collect the fractions.
- Hydrocarbons with the smallest molecules have the lowest boiling points and so are collected at the top of the column. The fractions collected at the bottom of the column contain hydrocarbons with the highest boiling points.

1 Why are different hydrocarbons collected at different levels of a fractional distillation column?

- Fractions with low boiling ranges have low **viscosity** so they are runny liquids. They are very **flammable** so they ignite easily. They also burn with clean flames, producing little smoke. This makes them very useful as fuels.

2 What properties would you expect for a fraction that is collected one-third of the way up a fractionating column?

Key words: fractional distillation, viscosity, flammable

4.3 Burning fuels

Key points

- Burning hydrocarbons in plenty of air produces carbon dioxide and water.
- Burning hydrocarbons in a limited supply of air may produce carbon monoxide and solid particles.
- Any sulfur compounds in the fuel burn to produce sulfur dioxide.
- Oxides of nitrogen can be formed when fuels burn under extreme conditions.

Bump up your grade

If you are taking the Higher Tier paper, you should be able to write balanced symbol equations for the complete and incomplete combustion of a hydrocarbon when given its formula.

- When pure hydrocarbons burn completely they are **oxidised** to carbon dioxide and water. However, the fuels we use are not always burned completely. They may also contain other substances.

1 Write a word equation for the complete combustion of ethane.

- In a limited supply of air **incomplete combustion** may produce **carbon monoxide**. Carbon may also be produced and some of the hydrocarbons may not burn. This produces solid particles that contain soot (carbon) and unburnt hydrocarbons called **particulates**.

2 Name four possible products of the incomplete combustion of a hydrocarbon.

- Most fossil fuels contain sulfur compounds. When the fuel burns these sulfur compounds produce **sulfur dioxide**. Sulfur dioxide causes acid rain.
- At the high temperatures produced when fuels burn, oxygen and nitrogen in the air may combine to form **nitrogen oxides**. Nitrogen oxides also cause acid rain.

3 What environmental problem is caused by sulfur dioxide and nitrogen oxides?

Key words: oxidised, incomplete combustion, carbon monoxide, particulate, sulfur dioxide, nitrogen oxide

4.4 Cleaner fuels

Key points

- Many scientists believe that carbon dioxide from burning fuels causes global warming.
- Sulfur dioxide and nitrogen oxides cause acid rain.
- Particulates cause global dimming.
- Pollutants can be removed from waste gases after the fuel is burned.
- Sulfur can be removed from fuels before they are burned so less sulfur dioxide is given off.

- We burn large amounts of fuels and this releases substances that spread throughout the atmosphere and affect the environment.
- Burning any fuel that contains carbon produces carbon dioxide. Carbon dioxide is a greenhouse gas that many scientists believe is the cause of **global warming**. Incomplete combustion of these fuels produces the poisonous gas carbon monoxide. It can also produce tiny solid particulates that reflect sunlight and so cause **global dimming**.

1 Name the product of incomplete combustion that scientists believe causes global dimming.

- Burning fuels also produces sulfur dioxide and nitrogen oxides. These gases dissolve in water droplets and react with oxygen in the air to produce acid rain.
- We can remove harmful substances from waste gases before they are released into the atmosphere. Sulfur dioxide is removed from the waste gases from power stations. Exhaust systems of cars are fitted with catalytic converters to remove carbon monoxide and nitrogen oxides. Filters can remove particulates.



A combination of many cars in a small area and the right weather conditions can cause smog to be formed. This is a mixture of SMOke and FOG.

- Sulfur can be removed from fuels before they are supplied to users so that less sulfur dioxide is produced when the fuel is burned.

2 What two methods are used to reduce the amount of sulfur dioxide produced by burning fuels?

Key words: global warming, global dimming

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pages 180–181

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4.5 Alternative fuels

Key points

- Biodiesel can be made from vegetable oils.
- Biofuels are a renewable source of energy that could be used instead of fossil fuels.
- There are advantages and disadvantages of using biodiesel.
- Ethanol made from sugar is a biofuel.
- Hydrogen is a potential fuel for the future.

- **Biofuels** are made from plant or animal products and are renewable. **Biodiesel** can be made from vegetable oils extracted from plants.
- There are advantages to using biodiesel. For example, it makes little contribution to carbon dioxide levels. This is because the carbon dioxide given off when it burns was taken from the atmosphere by plants as they grew.
- There are also disadvantages, for example the plants that are grown for biodiesel use large areas of farmland.
- Ethanol made from sugar cane or sugar beet is a biofuel. It is a liquid and so can be stored and distributed like other liquid fuels. It can be mixed with petrol.

1 Name two biofuels.

How Science Works

- Using hydrogen as a fuel has the advantage that it produces only water when it is burned.
- However, it is a gas so it takes up a large volume. That makes it difficult to store in the quantities needed for combustion in engines.
- It can be produced from water by electrolysis but this requires large amounts of energy.

2 Give one advantage and one disadvantage of hydrogen as a fuel.

Plants absorb CO_2 as they grow



Converted to biodiesel



Cars run on biodiesel produce very little CO_2 overall, as CO_2 is absorbed by plants as the fuel is made

Key words: biofuel, biodiesel

AQA Examiner's tip

You do not need to remember specific examples of advantages and disadvantages of biodiesel, but should be able to evaluate any information that is given in the examination.



Growing plants for biodiesel uses a lot of farmland

- 1 Why is crude oil separated into fractions?
- 2 Name the products when ethane, C_2H_6 , burns completely.
- 3 Give three reasons why fractions with lower boiling points are more useful as fuels.
- 4 Name two fuels that can be made from renewable sources.
- 5 Some exhaust fumes contain particulates. What are particulates and how are they produced?
- 6 Explain why burning some fuels produces sulfur dioxide.
- 7 Propane, C_3H_8 , is used as a fuel for cookers. Explain why propane should always be burned in a plentiful supply of air.
- 8 Why are some scientists concerned about the carbon dioxide produced by burning fossil fuels?
- 9 Pentane has the formula C_5H_{12} . Draw a displayed formula for pentane and write down four facts about pentane that you can deduce from its formula.
- 10 Explain what happens in a fractional distillation column used to separate crude oil.
- 11 Write a balanced symbol equation for the complete combustion of ethanol, C_2H_5OH . [H]
- 12 Write a balanced symbol equation for the reaction of hydrogen with oxygen. Explain why scientists are interested in using hydrogen as a fuel. [H]

Chapter checklist



Tick when you have:

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| reviewed it after your lesson | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| revised once – some questions right | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| revised twice – all questions right | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |

Move on to another topic when you have all three ticks

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| Fuels from crude oil | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fractional distillation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Burning fuels | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Cleaner fuels | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Alternative fuels | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |