

**WEEK: 19**

**Week Beginning: 27/07/20**

**Subject: SCIENCE**

**Year: GCSE**

### **Lesson Objective:**

- To learn about hydrocarbons and their properties
- To learn about combustion and its equation
- To understand how fractional distillation is used to separate hydrocarbons

### **Keywords/ Concepts**

- Hydrocarbon
- Alkane
- Homologous Series
- Combustion
- Fractional Distillation

### **Class Worksheets**

- CGP Worksheet: Hydrocarbons

### **Homework**

- CGP Worksheets: More on hydrocarbons
- CGP Worksheets: Fractional Distillation
- Revision Resources on the Topic

### **Additional Notes**

- Hello everyone, I have added the 6-marker from last week as an optional task for those of you who would like complete it. The mark scheme is attached.

## Hydrocarbons

Organic chemistry is about compounds that contain **carbon**. **Hydrocarbons** are the simplest organic compounds. As you're about to discover, the **properties** of hydrocarbons make them really useful.

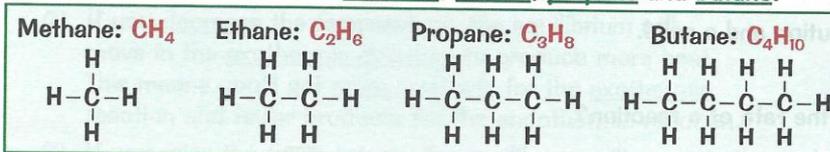
### Hydrocarbons Only Contain Hydrogen and Carbon Atoms

A hydrocarbon is any compound that is formed from **carbon and hydrogen atoms only**.

So  $C_{10}H_{22}$  (decane, an alkane) is a hydrocarbon, but  $CH_3COOC_3H_7$  (an ester) is **not** — it contains oxygen.

### Alkanes Have All C–C Single Bonds

- 1) **Alkanes** are the simplest type of hydrocarbon you can get. They have the general formula  $C_nH_{2n+2}$ .
- 2) The alkanes are a **homologous series** — a group of organic compounds that react in a similar way.
- 3) Alkanes are **saturated compounds** — each carbon atom forms four single covalent bonds.
- 4) The first four alkanes are **methane**, **ethane**, **propane** and **butane**.



A drawing showing all the atoms and bonds in a molecule is called a displayed formula.

Alkane, Al saw, Al conquered.

Give it a rest, Alan!



### Hydrocarbon Properties Change as the Chain Gets Longer

As the **length** of the carbon chain changes, the **properties** of the hydrocarbon change.

- 1) The **shorter** the carbon chain, the **more runny** a hydrocarbon is — that is, the **less viscous** (gooepy) it is.
- 2) Hydrocarbons with shorter carbon chains are also **more volatile**, i.e. they have lower boiling points.
- 3) Also, the **shorter** the carbon chain, the more **flammable** (easier to ignite) the hydrocarbon is.
- 4) The **properties** of hydrocarbons affect how they're used for fuels. E.g. **short chain** hydrocarbons with **lower** boiling points are used as 'bottled gases' — stored **under pressure** as **liquids** in bottles.

### Complete Combustion Occurs When There's Plenty of Oxygen

- 1) The **complete combustion** of any hydrocarbon in oxygen releases lots of energy. The only waste products are **carbon dioxide** and **water** vapour.

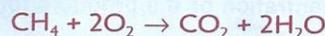
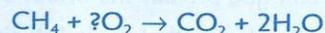
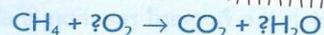


- 2) During combustion, both carbon and hydrogen from the hydrocarbon are **oxidised**.
- 3) Hydrocarbons are used as **fuels** due to the **amount of energy** released when they combust completely.
- 4) You need to be able to give a **balanced symbol equation** for the **complete combustion** of a simple hydrocarbon fuel when you're given its **molecular formula**. It's pretty easy — here's an example:

#### EXAMPLE:

Write a balanced equation for the complete combustion of methane ( $CH_4$ ).

- 1) On the **left hand side**, there's **one** carbon atom, so only **one** molecule of  $CO_2$  is needed to balance this.
- 2) On the **left hand side**, there are **four** hydrogen atoms, so **two** water molecules are needed to balance them.
- 3) There are **four** oxygen atoms on the **right hand side** of the equation. **Two** oxygen molecules are needed on the left to balance them.



Oxidation can be defined as the gain of oxygen.

See p.99 for more on balancing equations.

### The name's bond — single covalent bond...

So hydrocarbons only contain two ingredients — carbon and hydrogen. Jamie Oliver would not be happy.

Q1 Robyn has two alkanes,  $C_5H_{12}$  and  $C_{10}H_{22}$ . Compare the following properties of the alkanes:

- a) viscosity   b) boiling point   c) flammability

[3 marks]

Q2 Write a balanced symbol equation for the complete combustion of propane,  $C_3H_8$ .

[2 marks]

# Fractional Distillation

**Crude oil** can be used to make loads of useful things, such as fuels. But you can't just put crude oil in your car. First, the different hydrocarbons have to be separated. That's where **fractional distillation** comes in.

## Crude Oil is Made Over a Long Period of Time

- 1) **Crude oil** is a **fossil fuel**. It's formed from the remains of plants and animals, mainly **plankton**, that died millions of years ago and were buried in mud. Over millions of years, with high temperature and pressure, the remains turn to crude oil, which can be **drilled up** from the rocks where it's found.
- 2) Fossil fuels like coal, oil and gas are called **non-renewable fuels** as they take so long to make that they're being **used up** much faster than they're being formed. They're **finite** resources (see p.161) — one day they'll run out.

## Fractional Distillation can be Used to Separate Hydrocarbon Fractions

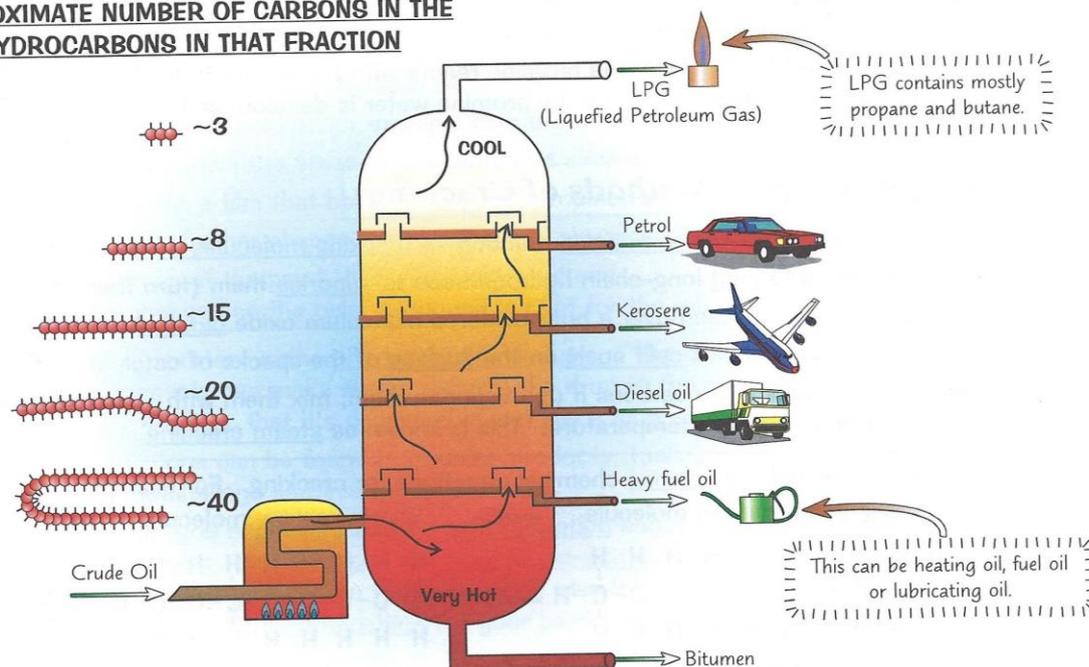
Crude oil is a **mixture** of **lots of different hydrocarbons**, most of which are **alkanes**. The different compounds in crude oil are **separated** by **fractional distillation**.

Hydrocarbons are molecules containing only hydrogen and carbon.

Here's how it works:

- 1) The oil is **heated** until most of it has turned into **gas**. The gases enter a **fractionating column** (and the liquid bit is drained off).
- 2) In the column there's a **temperature gradient** (it's **hot** at the **bottom** and gets **cooler** as you go up).
- 3) The **longer hydrocarbons** have **high boiling points**. They condense back into **liquids** and **drain out** of the column **early on**, when they're near the **bottom**. The **shorter hydrocarbons** have **lower boiling points**. They condense and drain out much **later on**, near to the **top** of the column where it's cooler.
- 4) You end up with the crude oil mixture separated out into **different fractions**. Each fraction contains a mixture of hydrocarbons that all contain a similar number of **carbon atoms**, so have similar **boiling points**.

### APPROXIMATE NUMBER OF CARBONS IN THE HYDROCARBONS IN THAT FRACTION



## How much petrol is there in crude oil? Just a fraction...

Make sure you understand how fractional distillation works — it might just save your life... OK, maybe not.

- Q1 Petrol drains further up a fractionating column than diesel. What does this suggest about the boiling points of the hydrocarbons which make up petrol compared to those in diesel? [1 mark]
- Q2 Describe the temperature gradient in a fractionating column used for fractional distillation. [1 mark]

Topic C7 — Organic Chemistry

# Hydrocarbons

## Warm-Up

Place each of the compounds on the left, below in the correct column of the table depending on whether or not they are hydrocarbons.

propane                      ethene

butanoic acid

$C_2H_6$

$CH_3CH_2Cl$

$C_2H_4$

hydrochloric acid

Hydrocarbon	Not a hydrocarbon

1 Alkanes are a family of hydrocarbons.



1.1 What is a hydrocarbon?

..... [1]

1.2 Which of the following shows the first four alkanes in order of decreasing carbon chain length? Tick **one** box.

Propane, ethane, butane, methane

Methane, ethane, propane, butane

Ethane, methane, butane, propane

Butane, propane, ethane, methane

[1]

1.3 Write the general formula of alkanes in terms of  $n$ , where  $n$  is the number of carbon atoms.

..... [1]

1.4 Complete the word equation for the complete combustion of a hydrocarbon.

hydrocarbon + oxygen  $\rightarrow$  ..... + ..... [1]

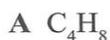
1.5 During a combustion reaction, are the atoms in the hydrocarbon oxidised or reduced?

..... [1]

[Total 5 marks]

Topic C7 — Organic Chemistry

2 The molecular formulas for five hydrocarbons, A to E, are shown below.



2.1 Which hydrocarbon is butane?

..... [1]

2.2 Which of the hydrocarbons are alkanes? Explain your answer.

.....  
 ..... [2]

2.3 Which of the hydrocarbons is likely to have the highest boiling point? Explain your answer.

.....  
 ..... [2]

[Total 5 marks]

3 Petrol and diesel are both fuels containing mixtures of hydrocarbons. The average chain length of the hydrocarbons in petrol and diesel are different, which causes diesel to have a higher boiling point than petrol.



3.1 Compare the viscosity of petrol and diesel.

Explain your answer with reference to the information above.

.....  
 ..... [2]

3.2 Predict whether petrol or diesel will be more flammable.

Explain your answer with reference to the information above.

.....  
 ..... [2]

3.3 Diesel contains alkanes that have 20 carbon atoms.

Give the molecular formula of an alkane with 20 carbon atoms.

..... [1]

3.4 Petrol contains alkanes with 8 carbon atoms.

Finish and balance the equation for the complete combustion of this hydrocarbon



[2]

[Total 7 marks]







## Fractional Distillation

1 Crude oil is a finite resource.



1.1 What is crude oil formed from?

..... [1]

1.2 What does 'finite resource' mean?

.....  
 ..... [1]

1.3 What type of substance does crude oil mainly consist of?  
 Tick **one** box.

Alkenes

Alkanes

Alcohols

Water

[1]

[Total 3 marks]

2 Fractional distillation is used to separate the mixture of molecules in crude oil into fractions such as petrol and diesel oil.



2.1 What property of the molecules in crude oil is used to separate them into different fractions?

..... [1]

2.2 Explain how a fractionating column separates the molecules in crude oil into different fractions.

.....  
 .....  
 .....  
 ..... [3]

2.3 Fractions boil over a range of temperatures much narrower than the original crude oil. What does this suggest about the structures of the hydrocarbons in a fraction?

..... [1]

[Total 5 marks]



Topic C7 — Organic Chemistry

Blood is transported around the body in arteries, veins, and capillaries. Describe the features of these blood vessels and explain how they relate to the vessels' functions.

*In this question you will be assessed on the quality of your English, the organisation of your ideas and your use of appropriate specialist vocabulary.*

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(6 marks)

### Mark Scheme:

Blood is transported around the body in arteries, veins and capillaries. Describe the features of these blood vessels and explain how they relate to the vessels' functions.

- 0 marks: No mention of the features of the functions of the blood vessels or how the features relate to the vessels' functions.
- 1-2 marks: A brief description of the features and/or functions of one or two blood vessels, with no mention of how the features relate to the vessels' function.
- 3-4 marks: A description of the features and functions of all the blood vessels, with a brief explanation of how some of the features relate to those vessels' functions. The answer has a logical structure and spelling, grammar and punctuation are mostly correct.
- 5-6 marks: A clear, detailed and full descriptions of the features and functions of all the blood vessels, with a full explanation of how all of the features relate to the vessels' functions. The answer has a logical structure and uses correct spelling, grammar, and punctuation.

Here are some points your answer may include:

Arteries carry blood away from the heart at high pressure, so the muscular walls are strong and elastic to withstand this pressure. The walls are also thick compared to the size of the lumen, again to withstand the high pressure.

Capillaries carry the blood close to every cell in the body in order to exchange substances with them. As a result, they have permeable walls that are only one cell thick. This increases the rate of diffusion by decreasing the distance over which it occurs.

Veins carry blood to the heart at low pressure. This means the walls don't need to be as thick as in arteries. They have a bigger lumen than arteries to help the blood flow despite the low pressure. They also have valves to help keep the blood flowing in the right direction despite the low pressure.