Highsted Knowledge Organiser Chemistry: Organic chemistry

What I need to know

What hydrocarbons are
The first four alkanes and the general formula for alkanes
Explain how fractional distillation works
Describe the cracking process
Understand how the physical properties of hydrocarbons change with chain length
Describe how to test for alkenes

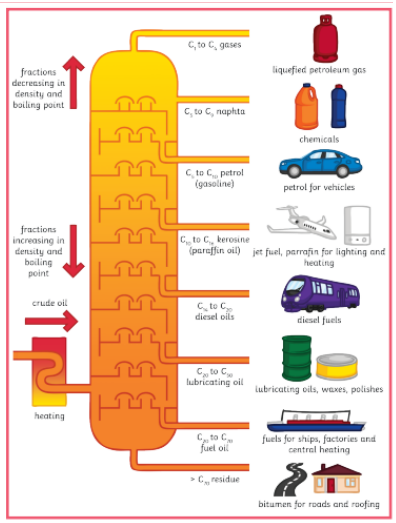
Key Vocabulary:

- **Hydrocarbon**
- **Alkane**
- **Alkene**
- **Bond**
- **Fractional distillation**
- **Cracking**
- **Catalyst**
- **Boiling point**
- **Viscosity**
- **Flammability**

Student reference point

Hydrocarbons are compounds that contain **carbon** and **hydrogen** only.
Alkanes are hydrocarbons held together by single bonds.
The general formula for an alkane is C_nH_{2n+2}

Fractional distillation is used to separate crude oil (a mixture of hydrocarbons) based on their boiling points. Crude oil is vaporised, fed into a fractionating column which is hot at the bottom and cool at the top.
Fractions condense once they reach their boiling point and are collected as liquids. Fractions contain hydrocarbons of a similar chain length.

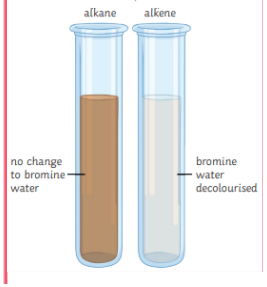


Combustion

Complete combustion occurs when there is **enough oxygen** for a fuel to burn. A hydrocarbon will react with oxygen to produce carbon dioxide and water.

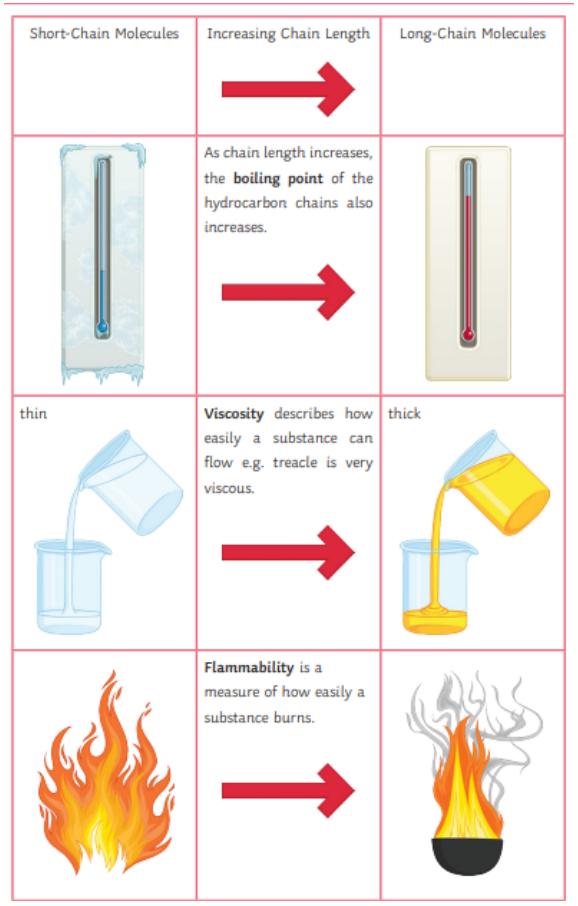
Incomplete combustion occurs when there **isn't enough oxygen** for a fuel to burn. The products in this reaction are water and poisonous **carbon monoxide**.

Name of Alkane	Structural Formula	Molecular Formula
methane		CH_4
ethane		C_2H_6
propane		C_3H_8
butane		C_4H_{10}



Cracking is a thermal decomposition reaction that breaks down long-chain hydrocarbons into shorter, more useful alkanes and an alkene.
Cracking involves heating a hydrocarbon to a high temperature and passing it over a catalyst.

Testing for alkenes
When bromine water is added to an alkane, it remains brown/orange.
When bromine water is added to an alkene, it turns colourless.
This is because alkenes are unsaturated hydrocarbons, so the double bond breaks and the bromine molecule is accepted.



Challenge question: Explain how alkenes are produced using fractional distillation followed by cracking (6 marks).

Suggested reading: Organic chemistry - Summary notes, mind maps and exam questions - AQA Separate Chemistry - Physics and maths tutore

Highsted Knowledge Organiser Chemistry: Organic chemistry

What I need to know

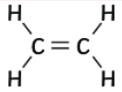
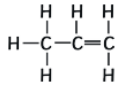
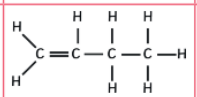
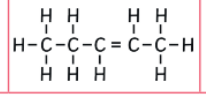
The first four alkenes and the general formula for alkenes
Reactions of alkenes with hydrogen, alcohols and halogens
The first four alcohols
The fermentation process
Reactions of alcohols with sodium, combustion and oxidation
The first four carboxylic acids
How esters are formed

Key Vocabulary:

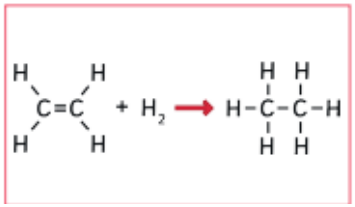
- **Alkene**
- **Addition reaction**
- **Combustion**
- **Alcohol**
- **Fermentation**
- **Functional group**
- **Carboxylic acid**
- **Ester**

Student reference point

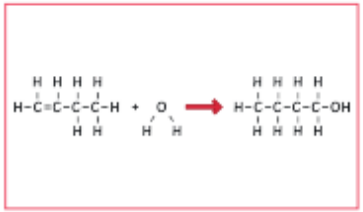
Alkenes are unsaturated hydrocarbons, they contain a double bond.
The general formula is C_nH_{2n}

Name of Alkene	Structural Formula	Molecular Formula
ethene		C_2H_4
propene		C_3H_6
butene		C_4H_8
pentene		C_5H_{10}

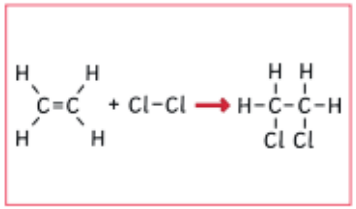
Alkenes undergo combustion, but burn with a smoky flame and tend to undergo incomplete combustion.
Alkenes take part in **addition** reactions. They react with hydrogen, in hydrogenation, which requires a catalyst and produces an alkane.



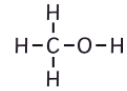
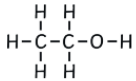
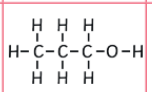
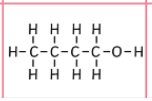
Alkenes react with water to produce an **alcohol**. This requires a high temperature and a catalyst.



Alkenes react with halogens to produce an alkyl halide.



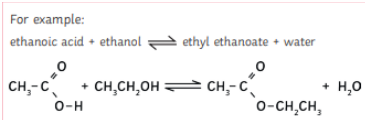
Alcohols all belong to the same homologous group, they have the same functional group (-OH, hydroxyl group)

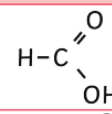
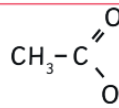
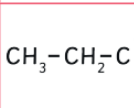
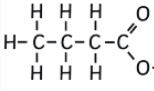
Name of Alcohol	Structural Formula	Molecular Formula	Uses
methanol		CH_3OH	chemical feedstock
ethanol		C_2H_5OH	alcoholic drinks, fuels and solvents
propanol		C_3H_7OH	fuels and solvents
butanol		C_4H_9OH	fuels and solvents

Ethanol is produced by fermentation, this requires yeast and a warm temperature, it is an anaerobic process.
Complete combustion of alcohols produces carbon dioxide and water.
Ethanol reacts with sodium to produce sodium ethoxide and hydrogen gas.

$$2Na + 2C_2H_5OH \longrightarrow 2C_2H_5ONa + H_2$$

Alcohols can be oxidised to produce a **carboxylic acid**.
Carboxylic acids contain the same functional group (-COOH).
They are weak acids and react with bases to produce a salt and water or with carbonates to produce a salt, water and carbon dioxide.
When a **carboxylic acid** is heated with an alcohol in the presence of an acid catalyst an **ester** is formed.
Esters have the functional group –COO–



Name of Carboxylic Acid	Structural Formula	Molecular Formula
methanoic acid		HCOOH
ethanoic acid		CH_3COOH
propanoic acid		C_2H_5COOH
butanoic acid		C_3H_7COOH

Challenge question: State what is formed when propene reacts with hydrogen and ethene reacts with water. Draw what is formed when butene reacts with bromine (4 marks)

Suggested reading: Organic chemistry - Summary notes, mind maps and exam questions - AQA Separate Chemistry - Physics and maths tutore

Highsted Knowledge Organiser Chemistry: Organic chemistry

What I need to know

What addition polymers are
The structure of DNA
What proteins, starch and cellulose are made from
The repeating unit for a protein given the amino acids

Key Vocabulary:

- **Addition polymer**
- **Condensation polymer**
- **DNA**
- **Amino acid**
- **Protein**

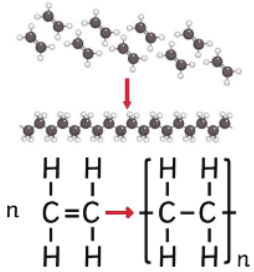
Student reference point

Addition Polymerisation

Addition polymerisation occurs when **two or more monomers** join together to form a **polymer**.
For example, during the polymerisation of ethene, many monomers (single units of ethene) are joined together to make poly(ethene). **Poly** meaning '**many**' (many ethene molecules joined together).

The number of ethene molecules that are joined together could be in the thousands, therefore, when writing the equation the letter 'n' is used to represent the **large number of molecules**.

Notice that the **monomer** of **ethene** has a **double bond**. When it bonds to form **poly(ethene)** the double bond breaks and a **single bond** is formed.



Biological Polymers

DNA (deoxyribonucleic acid) is an example of a **naturally occurring polymer**. DNA is a **double helix** (twisted ladder) and it is made up of two polymer chains that are twisted to form a double helix. The **monomers** of the two polymer chains are called **nucleotides**. The four nucleotides in DNA are called adenine, guanine, cytosine and thyroxine. The nucleotide sequence codes for genes. **Genes** are **sections of DNA** that determine an organisms characteristics.

Proteins are another example of a naturally occurring polymer. Proteins are made from individual **monomer** units called **amino acids**. Proteins have many roles within our bodies; all enzymes are made from proteins.

Plants make the biological polymers **starch** and **cellulose**. They are made up of individual **monomer** units of **sugar** molecules. **Plants** use **starch** as a way to **store energy**. **Cellulose** is used by plants to give the **cell wall strength**.

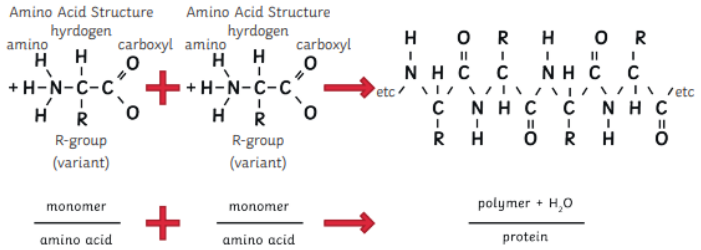
Amino Acids – Higher Tier Only

There are 20 different types of amino acids and when arranged in a particular order, they produce the proteins that are found within our cells.

An amino acid is a molecule that has two functional groups. The amine group (NH_2) and the carboxyl group (**COOH**). In between these two functional groups is a single carbon atom with a hydrogen atom bonded to it, along with another group.

Amino acids bond together through the process of a **condensation polymerisation** reaction.

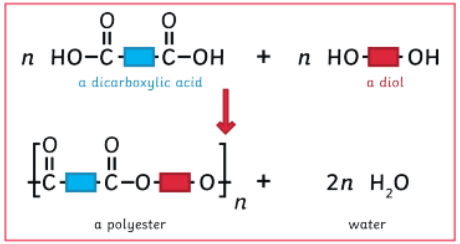
For every **monomer** (amino acid) that is added to the growing chain of the **polymer**, a molecule of **water** is **produced**.



Amino Acids – Higher Tier Only

Addition polymerisation requires the monomers to have a **C=C double bond**. **Condensation polymerisation** does not require a C=C double bond but does need **two functional groups**. When two monomers react, a **water molecule** is usually **produced**.

An example of a condensation polymer is polyester. Polyester is made from one **monomer** that has **two hydroxyl groups** and another monomer which has **two carboxylic acid groups**.



Challenge question: From memory—Describe the structure of DNA (2 marks)

Suggested reading: Organic chemistry - Summary notes, mind maps and exam questions - AQA Separate Chemistry - Physics and maths tutore

Highsted Knowledge Organiser Chemistry: Chemical analysis

What I need to know

What a pure substance is
What a formulation is
How to carry out a chromatography practical
How to calculate and compare Rf values
How to identify hydrogen, oxygen, carbon dioxide and chlorine gas
How to carry out a flame test and the colours for lithium, sodium, potassium, calcium and copper

Key Vocabulary:

- **Pure substance**
- **Formulation**
- **Paper chromatography**
- **Rf value**
- **Splint**
- **Limewater**
- **Litmus paper**
- **Flame test**
- **Wire loop**

Student reference point

Pure substances, in chemistry, only contain **one type of element** or **one type of compound**. For example, pure water will just contain water (a compound).

Formulations are **mixtures of compounds or substances** that **do not react together**. They do **produce a useful product** with desirable characteristics or properties to suit a particular function.

There are examples of formulations all around us such as medicines, cleaning products, deodorants, hair colouring, cosmetics and sun cream.

Required Practical – Paper Chromatography

Investigate how paper chromatography can be used to separate and distinguish between coloured substances.

Step 1 – Using a ruler, measure 1cm from the bottom of the chromatography paper and mark with a small dot using a pencil. Rule a line across the bottom of the chromatography paper with a pencil, going through the dot you have just made.

Step 2 – Using a pipette, drop small spots of each of the inks onto the pencil line. Leave a sufficient gap between each ink spot so that they do not merge.

Step 3 – Get a container and pour a suitable solvent into the bottom. The solvent should just touch the chromatography paper. The solvent line must not go over the ink spots as this will cause the inks to run into each other.

Step 4 – Place the chromatography paper into the container and allow the solvent to move up through the paper.

Step 5 – Just before the solvent line reaches the top of the paper, remove the chromatogram from the container and allow to dry.

Step 6 – Once the chromatogram has dried, measure the distance travelled by the solvent.

Step 7 – Measure the distance travelled by each ink spot.

Step 8 – Calculate the R_f value. Compare the R_f value for each of the spots of ink.

$$R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$$

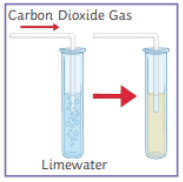
Identification of the Common Gases

The Test for Hydrogen

Place a burning splint at the opening of a test tube. If hydrogen gas is present, it will burn rapidly with a **squeaky-pop sound**.

The Test for Oxygen

Place a glowing splint inside a test tube. The **splint will relight** in the presence of oxygen.



The Test for Carbon Dioxide

Calcium hydroxide (lime water) is used to test for the presence of carbon dioxide. When carbon dioxide is bubbled through or shaken with limewater, the limewater turns **cloudy**.

The Test for Chlorine

Damp litmus paper is used to test for chlorine gas. The litmus paper becomes **bleached and turns white**.

Flame Tests

Metal ions when heated produce a variety of flame colours. Flame tests are used to **identify** the **metal ion** that is present; each metal ion produces a different coloured flame.

Step 1 – Dip a wire loop into a sample of the solid compound being tested.

Step 2 – Place the loop into the flame of the Bunsen burner. Ensure that the Bunsen burner is set to a roaring blue flame.

Step 3 – Observe the colour of the flame produced and record it in a table.

Mixtures of ions may cause some flame colours to not be as clear.

Ion	Colour of the Flame
Li^+	 crimson
Na^+	 yellow
K^+	 lilac
Ca^{2+}	 orange-red
Cu^{2+}	 green

Challenge question: Design a practical to distinguish between samples of lithium chloride, potassium chloride and copper chloride and give the expected results (6 marks)

Suggested reading: Chemical analysis - Revise, videos, tests - AQA Separate Chemistry - BBC bitesize

Highsted Knowledge Organiser Chemistry: Organic chemistry

What I need to know

How to identify metals from their reactions with sodium hydroxide solution
How to test for carbonate ions
How to test for sulphate ions
How to test for halide ions
What flame emission spectroscopy is

Key Vocabulary:

- **Precipitate**
- **Sodium hydroxide**
- **Hydrochloric acid**
- **Limewater**
- **Barium chloride**
- **Silver nitrate solution**
- **Flame emission spectroscopy**

Metal Hydroxides

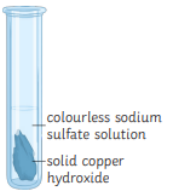
In order to identify metal ions, **sodium hydroxide solution** is added. Solutions of calcium, magnesium and aluminium all form white precipitates. Only the aluminium hydroxide **precipitate** dissolves in excess sodium hydroxide. Iron (II), iron (III) and copper (II) all form coloured precipitates when sodium hydroxide solution is added.

magnesium sulfate + sodium hydroxide ⟶ magnesium hydroxide + sodium sulfate

$MgSO_4 + 2NaOH \longrightarrow Mg(OH)_2 + Na_2SO_4$

Ion	Colour of the Precipitate Produced
Al^{3+}	white
Ca^{2+}	white
Mg^{2+}	white

Ion	Colour of the Precipitate Produced
Cu^{2+}	blue
Fe^{2+}	green
Fe^{3+}	brown



Testing for Carbonate Ions (CO_3^{2-}) Chemistry Only

Place a small volume of limewater into a test tube. In a separate test tube, add a small sample of the **carbonate** and add a few drops of **hydrochloric acid** (acids are a source of H^+ ions) using a pipette. Seal the test tube with a bung connected to a delivery tube; the delivery tube should be placed in the test tube containing the limewater. Bubbles of **carbon dioxide** gas will be produced. The **limewater will turn a milky colour** indicating a positive test for carbon dioxide.

$CO_3^{2-} + 2H^+ \longrightarrow CO_2 + H_2O$

Testing for Sulfate Ions (SO_4^{2-})

Using a pipette, add a few drops of **barium chloride** solution to the sample followed by a few drops of **hydrochloric acid**. A positive result for sulfate ions will produce a white precipitate.

$SO_4^{2-} + Ba^{2+} \longrightarrow BaSO_4$

Testing for Halide Ions (I^-, Br^-, Cl^-)

Using a pipette, add a few drops of dilute **nitric acid** to the sample followed by a few drops of **silver nitrate solution**. Leave it to stand and **observe the colour** of the **precipitate formed**.

Each halide ion produces a different coloured precipitate.

- **Chloride** produces a **white** precipitate.
- **Bromide** ions produce a **cream** precipitate.
- **Iodide** ions produce a **yellow** precipitate.

Flame Emission Spectroscopy

Flame emission spectroscopy is an instrumental method of analysis. The benefits of instrumental methods of analysis are that it is **rapid, accurate and sensitive**. The drawbacks to such methods are that the equipment is often **expensive** and **requires special training** to use.

Flame emission spectroscopy is a technique that is used to **identify** metal ions in solution. The samples that are tested normally include biological fluids and tissues.

Challenge question: Design a practical to distinguish between samples of sodium carbonate, sodium sulphate and sodium bromide (6 marks)

Suggested reading: Chemical analysis - Revise, videos, tests - AQA Separate Chemistry - BBC bitesize