Crude Oil

Hydrocarbons are compounds that are made up of the elements **hydrogen** and **carbon** only.

Crude oil is a **non-renewable resource**, **a fossil fuel**. Crude oil is made up of a mixture of compounds, most of which are long- and short-chain hydrocarbons.

Most of the compounds in crude oil are hydrocarbons called **alkanes**. The alkanes form a **homologous series**. This is a family of hydrocarbons that all share the **same general formula** and have **chemical properties** that are **similar**.

Alkanes are held together by **single bonds**.

The general formula for an alkane is C_nH_{2n+2}.

They differ from the neighbouring alkane with the addition of a CH_2.

Alkanes are **saturated hydrocarbons**. This means that all their bonds are taken up and they cannot bond to any more atoms.

Alkanes have **similar chemical properties** but have **different physical properties** due to differences in chain length. The longer the chain, the higher the boiling point of the hydrocarbon.

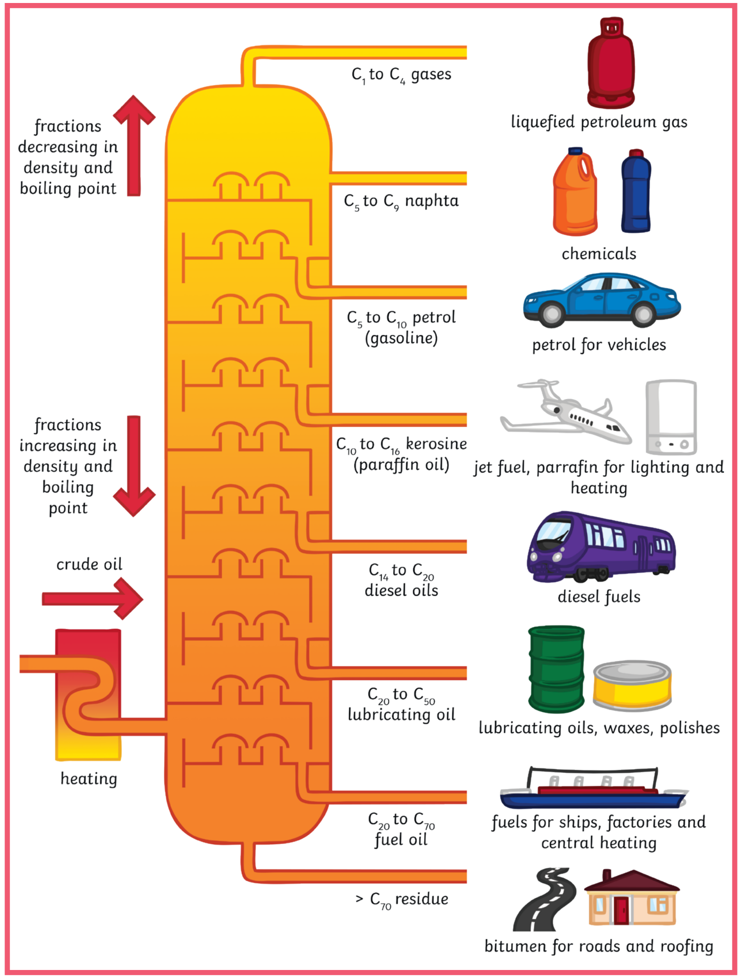
The first four alkanes are: methane, ethane, propane and butane.

A mnemonic to help you remember the order of the alkanes: **m**ice **e**at **p**aper **b**ags.

Fractional Distillation

Fractional distillation is used to **separate** a mixture of long-chain hydrocarbons in crude oil into smaller, more useful fractions.

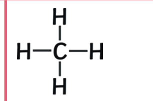
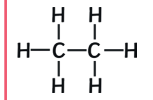
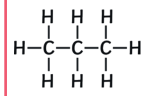
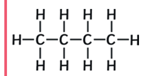
Hydrocarbons have different boiling points depending on their chain length. **Each fraction contains hydrocarbons of a similar chain length**. These fractions will boil at different temperatures due to the difference in sizes of the molecules. The different parts of crude oil are called fractions because they are a small part of the original mixture.



Crude oil is heated and enters at all column called a **fractioning column**. The column is **hot at the bottom** and decreases in temperature toward the top. As the crude oil is heated, it begins to evaporate and its vapours begin to rise up through the column. These vapours condense at the different fractions.

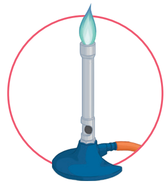
Short-chain hydrocarbons are found at the **top** of the column. This is because shorter chain molecules are held together by **weak intermolecular forces** resulting in low boiling points. These shorter chain hydrocarbons leave the column as gas.

Long-chain hydrocarbons are found at the bottom of the column and are held together by **strong intermolecular forces**, resulting in high boiling points.

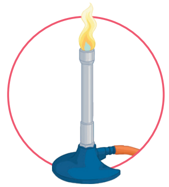
Name of Alkane	Structural Formula	Molecular Formula
methane		CH_4
ethane		C_2H_6
propane		C_3H_8
butane		C_4H_{10}

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**.



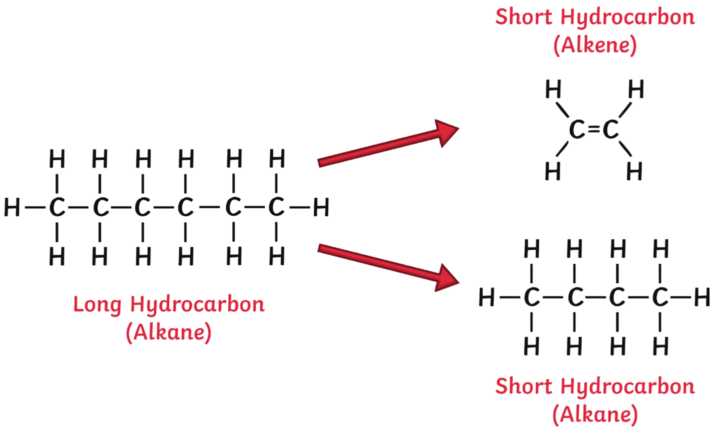
Cracking

Cracking is an example of a **thermal decomposition reaction. Long-chain** hydrocarbons can be **broken** down into **shorter**, more useful hydrocarbon chains.

Cracking can be carried out with a catalyst in **catalytic cracking** or with steam in **steam cracking**.

Catalytic cracking involves heating a hydrocarbon to a high temperature (550˚C) and passing over a hot catalyst.

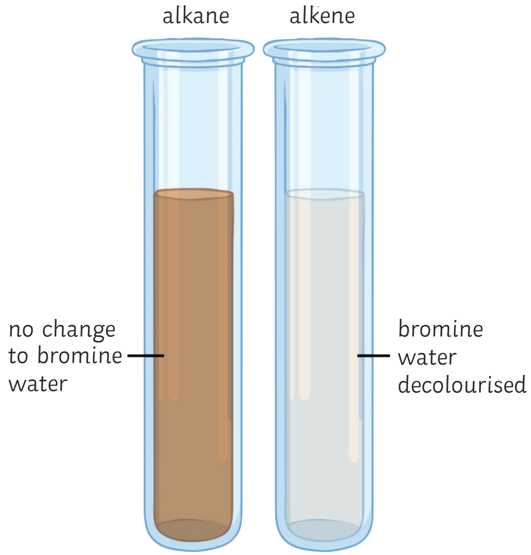
Cracking of a long-chain hydrocarbon **produces** a **short-chain alkane** and an **alkene**.



Test for Alkanes

Bromine, when added to an **alkane**, will **remain brown/ orange**. Alkanes are saturated hydrocarbons, they have no double bonds which could be broken to accept the bromine molecule and so remain orange.

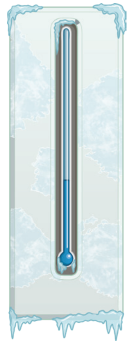
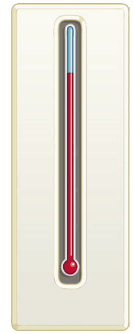
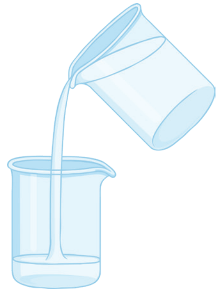
Bromine, when added to an **alkene**, will **change from brown/orange to colourless**. This is because alkenes are unsaturated hydrocarbons. The double bond breaks and the bromine molecule is accepted.



Making Polymers

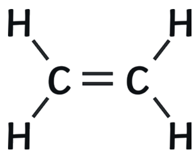
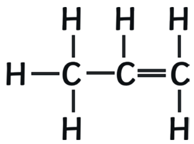
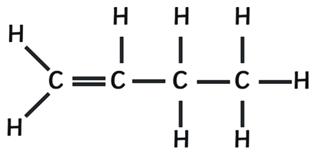
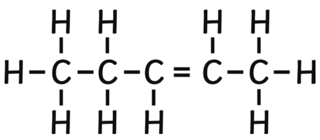
The fractional distillation of crude oil and cracking produces an array of hydrocarbons that are **key** to our **everyday lives.**

Alkenes are used to produce plastics such as poly(ethene) which is used to make plastic bags, drinks bottles and dustbins. Poly(propene), another polymer, forms very strong, tough plastic.

Short-Chain Molecules	Increasing Chain Length	Long-Chain Molecules
	As chain length increases, the **boiling point** of the hydrocarbon chains also increases.	
thin 	**Viscosity** describes how easily a substance can flow e.g. treacle is very viscous.	thick 
	**Flammability** is a measure of how easily a substance burns.	

AQA GCSE Chemistry (Separate Science) Unit 7: Organic Chemistry Knowledge Organiser

Alkenes (Chemistry Only)

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

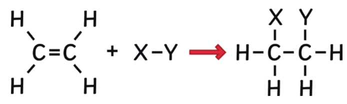
Alkenes are another type of hydrocarbon that is double bonded. The general formula for an alkene is C_nH_{2n}.

Alkenes are **unsaturated hydrocarbons**. In a chemical reaction, the double bond of the alkenes can break. This allows other molecules to bond to it. Note that alkenes all have the suffix '**ene**'.

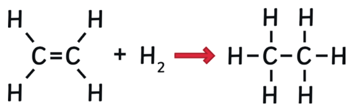
Reactions of Alkenes (Chemistry Only)

Alkenes, just like alkanes, also undergo **combustion** reactions. Alkenes rarely combust completely and tend to undergo **incomplete combustion**. When burning in the air, they produce a smoky flame.

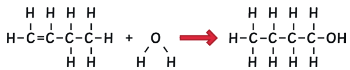
Alkenes have the functional group **C=C**. This double bond between the carbon atoms is able to undergo an addition reaction. This means that the double bond can break and will accept another molecule. **Alkanes** are **unable** to take part in **addition reactions** as their functional group is **C-C**. This means the bond cannot break in order to accept a new molecule.



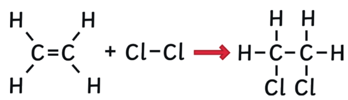
Alkenes are able to **react** with **hydrogen** in an addition reaction called **hydrogenation**. This particular reaction **requires** a **catalyst**.



Alkenes can also **react** with **water** to **produce** an **alcohol**. This is called a **hydration reaction**. The type of compound produced contains a hydroxyl group (-OH), this compound is an alcohol. The reaction **requires** a **high temperature** (300˚C) and a **catalyst**.

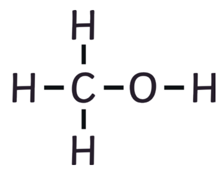
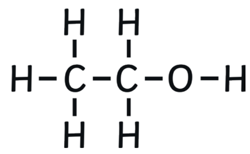
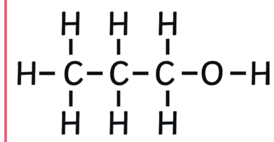
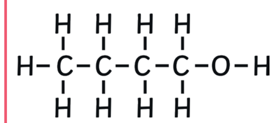


Addition reactions also occur with the **group 7 elements**, the **halogens**. The reaction is called a **halogenation reaction**. When an **alkene reacts** with a **halogen,** an **alkyl halide** is produced.



Alcohols (Chemistry Only)

Alcohols all belong to the **same homologous group**. This is a group of organic compounds that have the same functional group (**-OH, hydroxyl group**) and that have similar chemical properties but different physical properties to each other. Note that alcohols all have the suffix '**ol**'.

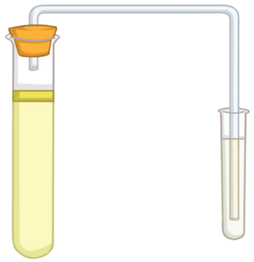
Name of Alcohol	Structural Formula	Molecular Formula	Uses
methanol		CH_3OH	chemical feedstock
ethanol		C_2H_5OH	alcoholic drinks, fuels and solvents
propanol		C_3H_7OH	fuels and solvents
butanol		C_4H_9OH	fuels and solvents

Fermentation

The alcohol that is found in beers, wines and spirits is called ethanol. Ethanol isn't just used in alcoholic drinks, it can also be used as a fuel in vehicles. Ethanol is made through the process of **fermentation**.

Fermentation is an **anaerobic process** and this means that it occurs **without oxygen**.

glucose ⟶ ethanol + carbon dioxide



The fermentation process requires yeast, sugar and water, a warm temperature between 25-35˚C and a reaction vessel that will allow **carbon dioxide** to **escape** but not allow oxygen to get in.

The enzymes needed for fermentation are provided by a single-celled fungus called **yeast**. If the temperature of the reaction mixture is too **cold**, the **fermentation** process will happen very **slowly** or not at all.

If the reaction mixture containing the yeast becomes too **hot**, the **enzymes** may become **denatured** and the process of **fermentation** will **stop**.

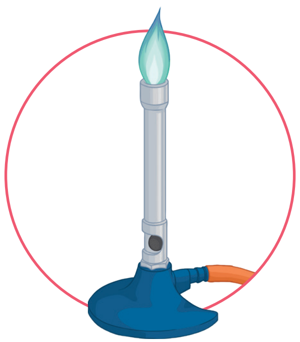
If **oxygen** is allowed to enter the reaction vessel, the **ethanol** will **oxidise** and form ethanoic acid making the drink taste of **vinegar**.

Combustion

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

ethanol + oxygen ⟶ carbon dioxide + water

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$



Reactions with Sodium Metal

When dropped into **ethanol**, **sodium** produces **sodium ethoxide** and **hydrogen gas**. Methanol, propanol and butanol all undergo a similar reaction with sodium.

The word equation for this reaction is:

sodium + ethanol ⟶ sodium ethoxide + hydrogen

The symbol equation for this reaction is:

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

Oxidation of Alcohol

Alcohols can be **oxidised** to produce a carboxylic acid. Carboxylic acids are a family of compounds that contain the functional group **–COOH** (carboxyl group). Note that carboxylic acids have the suffix '**oic acid**'. The carboxylic acids have varying physical properties but similar chemical properties.

Oxidation can mean a number of different things: the loss of electrons, the addition of oxygen or the removal of hydrogen. In a chemical equation, the oxidising agent is represented as **[O]**, this symbol means **oxygen from the oxidising agent**.

ethanol + oxidising agent ⟶ ethanoic acid + water

$$CH_3CH_2OH + 2[O] \longrightarrow CH_3COOH + H_2O$$

The equation can also be written in two stages. The first stage shows the formation of **ethanal** and the second stage shows its oxidation.

Stage 1: $CH_3CH_2OH + [O] \longrightarrow CH_3CHO + H_2O$

Stage 2: $CH_3CHO + [O] \longrightarrow CH_3COOH$

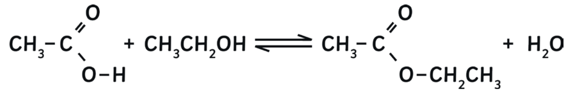
Carboxylic Acids

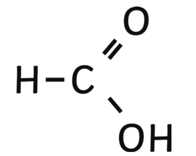
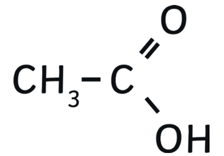
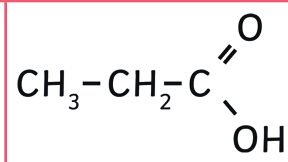
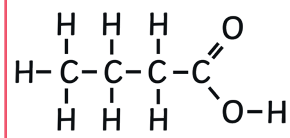
Carboxylic acids are able to react with bases to produce a salt and water. They are also able to react with carbonates to produce a salt, water and carbon dioxide.

When a carboxylic acid is heated with an alcohol in the presence of an acid catalyst (usually concentrated sulfuric acid), an **ester** is formed. Esters typically smell fruity and are used in perfumes. They have the functional group –**COO**-.

For example:

ethanoic acid + ethanol ⇌ ethyl ethanoate + water



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

Carboxylic acids are **acidic** due to the hydrogen in the functional group (COOH). When a carboxylic acid forms a salt, the hydrogen is lost and replaced with a metal.

Carboxylic Acids - Higher Tier Only

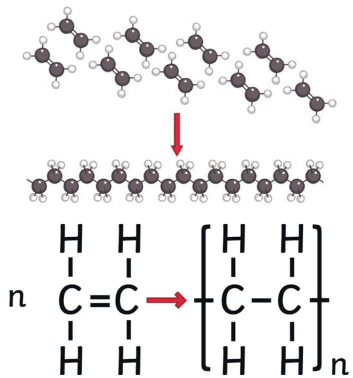
When dissolved in water, carboxylic acids are able to form **acidic solutions**. The pH of the solution is less than 7. They are **weak acids**. Carboxylic acid solutions contain **fewer hydrogen ions** compared with a solution that is the same concentration and contains a strong acid. **Strong acids** are **fully ionised** in solution whereas **weak acids** are only **partially ionised** in solution.

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**.

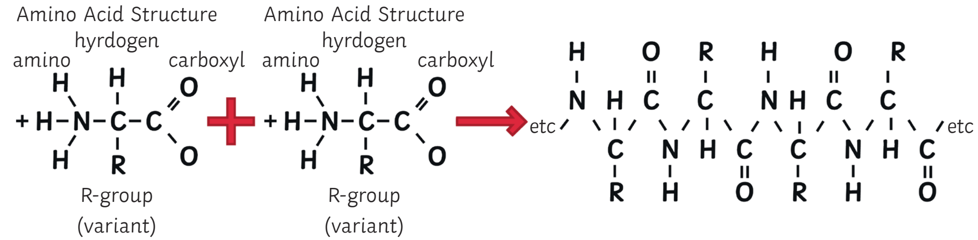
Amino Acids – Higher Tier Only

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**.



monomer / amino acid + monomer / amino acid → polymer + H_2O / protein

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**.