GCSE C7 – Organic Chemistry

science chemistry

1) What is organic chemistry?

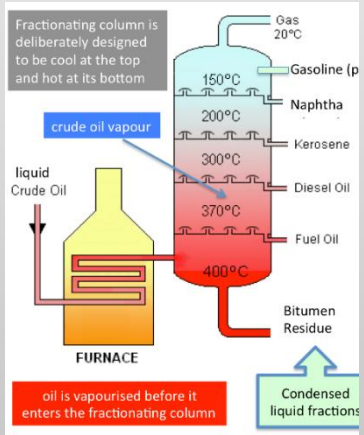
The study of the chemistry of carbon compounds. All living things are carbon based and there are so many carbon compounds because carbon atoms can form chains and rings.

2) Crude oil

Crude oil is a finite resource found in rocks and is the remains of ancient biomass consisting mainly of **plankton** that was **buried in mud**. **High temperature & pressure** over **millions of years** turns the organism remains into crude oil.
Crude oil is a mixture of **hydrocarbons** – compounds containing hydrogen and carbon **ONLY**

3) Fractional Distillation

Method of separating mixtures based on their boiling points.
Heat the crude oil until it becomes a **vapour.**
Put into tower with **temp gradient** (hot at bottom, colder at top)
The vapour **cools** and **condenses** at different heights in the tower.
Smaller molecules with lower boiling points will condense higher up the tower where it is colder. Larger molecules will condense lower down the tower.



small-sized molecules
short carbon-chain lengths
low boiling points
low viscosity (easily flows)
high flammability (ignites and burns easily)

large-sized molecules
long carbon-chain lengths
high boiling points
high viscosity (does not easily flow)
low flammability (does not ignite/burn easily)

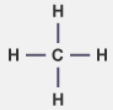
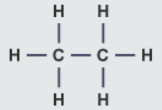
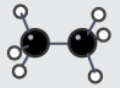
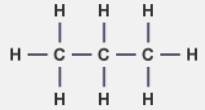
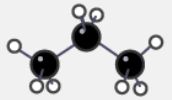
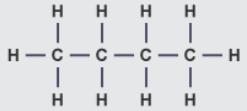
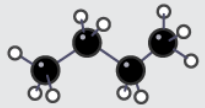
4) Properties of fractions

Boiling point – smaller molecules have lower boiling points
Flammability – smaller molecules burn better so are better fuels
Viscosity – smaller molecules are less viscous (flow easily)

5) The alkanes

These are the main group of hydrocarbons found in crude oil. They are a family of hydrocarbons with the same general formula – C_nH_{2n+2} (n is the number of carbon atoms).

They are saturated – only contain single bonds.

Alkane	Molecular formula	Structural formula	Ball-and-stick model
Methane	CH_4		
Ethane	C_2H_6		
Propane	C_3H_8		
Butane	C_4H_{10}		

6) Cracking Crude Oil

Thermal decomposition reaction breaking down the long hydrocarbon molecules into smaller ones (helps meet supply and demand).
Catalytic cracking – Hydrocarbons heated until they vaporise and then vapour passed over a hot aluminium oxide catalyst.
Steam cracking – Hydrocarbons mixed with steam and heated to about 850°C
e.g. Heptane cracked into 1 molecule of ethene and 1 molecule of pentane $C_7H_{16} \rightarrow C_2H_4 + C_5H_{12}$

Alkenes such as ethene (C_2H_4) are also made which can be turned into polymers.

7) Combustion

Combustion (burning) is an oxidation reaction which produces energy.
When there is a plentiful supply of oxygen **complete combustion** of hydrocarbons produces carbon dioxide and water

e.g. $CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2H_2O_{(l)}$

When there is a limited supply of oxygen, **incomplete combustion** produces either water and either carbon monoxide or just carbon (soot)

e.g. $CH_{4\,(g)} + 1.5O_{2\,(g)} \rightarrow CO_{(g)} + 2H_2O_{(l)}$

e.g. $CH_{4\,(g)} + O_{2\,(g)} \rightarrow C_{(s)} + 2H_2O_{(l)}$

8) Alkenes

- Cracking produces shorter alkanes which make better fuels
- Cracking also produces alkenes.

- We can test for alkenes using **bromine water** which goes from **orange to colourless** if alkenes are present.

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9) Alkenes

These are formed from the cracking of alkanes (see previous sheet). They are unsaturated hydrocarbons as they contain a carbon to carbon double bond and have the same general formula C_nH_{2n}. Alkenes react with oxygen in combustion reactions like alkanes but tend to produce slightly smokier flames due to incomplete combustion.

$C_2H_{4\,(g)} + 3O_{2\,(g)} \rightarrow 2CO_{2\,(g)} + 2H_2O_{(l)}$

Alkenes react with hydrogen gas at 60°C in the presence of a nickel catalyst. This is called hydrogenation and is used in the hardening of vegetable oils when making margarine

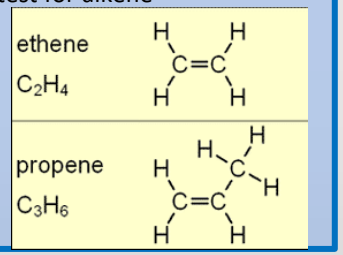
$C_5H_{10} + H_2 \rightarrow C_5H_{12}$

Alkenes react with water / steam at high temp and pressure over a phosphoric acid catalyst to produce alcohols.

$C_2H_4 + H_2O \rightarrow C_2H_5OH$

Alkenes react with halogens (this is the test for alkene – they decolourise bromine water)

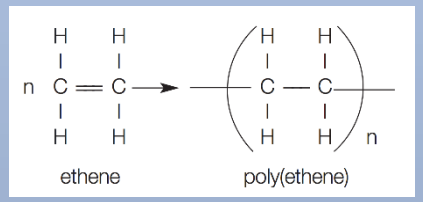
$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$



10) Polymers

Alkenes undergo **addition polymerisation** (adding lots of small molecules together to make a big one).

e.g. $nC_2H_4 \rightarrow -(-CH_2CH_2-)_n-$



Condensation polymerisation involves monomers with two functional groups . When these types of monomers react, they join together and usually lose small molecules, such as water. Examples include **polyesters, polyamides** & **DN**A

11) Alcohols

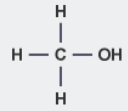
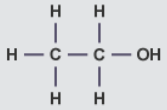
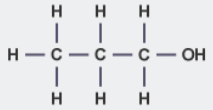
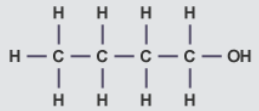
- Made when an aqueous solution of sugar is fermented using yeast at 35°C in the absence of oxygen. $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
- Alcohols react with oxygen and also undergo combustion

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

- Alkenes react with sodium to produce sodium ethoxide & hydrogen
- Alcohols undergo oxidation with an oxidising agent such as acidified potassium dichromate (VI) to make carboxylic acids

$C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$

This is a similar reaction to what happens when wine is left open for too long, the microbes in the air oxidise the alcohol and it smells like vinegar.

Name	Molecular formula	Full structural formula
Methanol	CH_3OH	
Ethanol	C_2H_5OH	
Propan-1-ol	C_3H_7OH	
Butan-1-ol	C_4H_9OH	

12) Carboxylic acids and esters

Carboxylic acids form acid solution when they dissolve in water, hence the term acid. As met in topic 4, acids will react with bases:

Ethanoic acid + sodium carbonate → sodium ethanoate + water + carbon dioxide

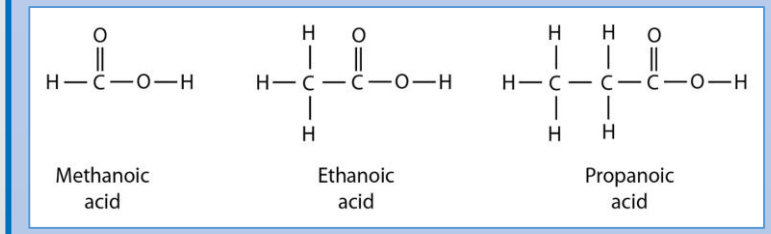
$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$

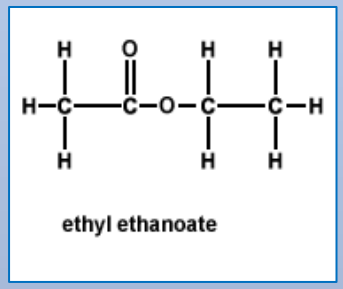
Carboxylic acids will react with alcohols to form esters:

Ethanoic acid + ethanol → ethyl ethanoate + water

$CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$

Esters often have sweet , fruity smells and are used in perfumes and food flavourings.





13) Amino Acids and DNA (a natural polymer)

- Amino acids have two different functional groups in a molecule
- They react by condensation polymerisation to produce polypeptides and proteins.
- DNA consists of two polymer chains (double helix), made from four different monomers called nucleotides.
- Nucleotides consist of a sugar molecule, a phosphate group and a base.
- Other natural polymers include proteins (made of amino acids) and starch (made of glucose).