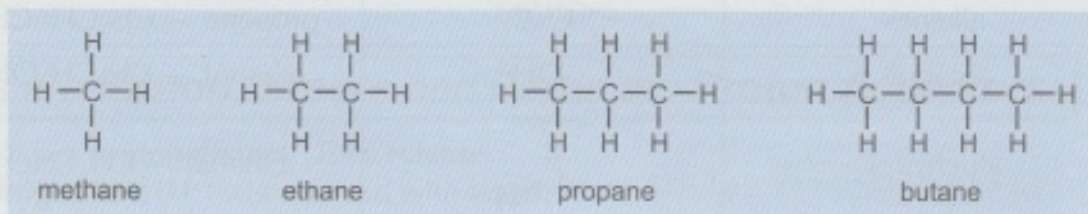


Alkanes

Structure and Bonding in Alkanes

- 1) Alkanes are **hydrocarbons** — they **only** contain hydrogen and carbon atoms.
- 2) Alkanes contain **two types** of bond. All of the **carbon-carbon** bonds are **single covalent bonds**. All the other bonds are **carbon-hydrogen covalent bonds** (which are always single).
- 3) All of the available bonds have been formed, so we call alkanes **saturated** molecules.
- 4) **Carbon** always forms **four** covalent bonds and **hydrogen** makes **one** covalent bond.
- 5) The diagrams below show the structures of the first four **straight-chain alkanes**: methane, ethane, propane and butane.



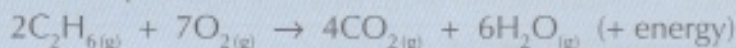
It is important to realise that these structures are only **2D representations** of the **3D molecules**. The molecules are not rigid. There is **free rotation** around a carbon-carbon single bond. This means that the carbon chains are quite **flexible** and gives the molecules the ability to **change shape**, particularly as the chain length increases.

Properties of Alkanes

The **bonds** in alkanes are very **strong** and it requires a **lot of energy** to break them. This can be used to explain some of their **properties**:

- 1) They are very **unreactive**.
- 2) They are **not** able to form **polymers**.
- 3) They **burn cleanly**, tending to undergo **complete combustion** to form **carbon dioxide** and **water** (see page 28). The flame is usually a faint blue colour.

For example, the combustion of ethane:



Also:

- 4) **Boiling point increases** as the **length** of the carbon chain increases.
- 5) **Viscosity** (resistance to flow) **increases** as chain length increases.
- 6) **Volatility** (ease of evaporation) **decreases** as chain length increases.

These last three properties are explained by the fact that the **attractive forces** between molecules get stronger as the chain length **increases** (page 9).



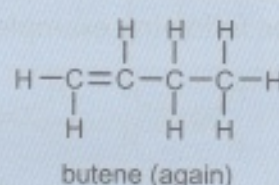
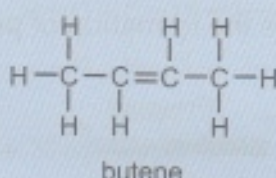
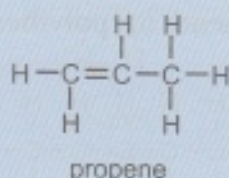
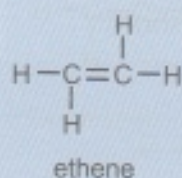
Alkanes are like the weather in the UK — completely saturated...

- 1) Draw out the structures of the next two alkanes, pentane (C_5H_{12}) and hexane (C_6H_{14}).
- 2) a) Write out the molecular formulae of the first four alkanes.
b) We can work out a general formula for the alkanes of the form $\text{C}_n\text{H}_?$, where n is the number of carbon atoms. Work out, in terms of n , what should be in place of the ?.
- 3) Write a balanced equation for the complete combustion of propane in oxygen.

Alkenes

Structure and Bonding in Alkenes

- 1) **Alkenes** are similar to alkanes in that they are also **hydrocarbons**. The difference is in the presence of a **carbon-carbon double covalent bond** (C=C) somewhere in the carbon chain.
- 2) This means **not** all possible single bonds have been made — these molecules are **unsaturated**.
- 3) As in all compounds the carbon atoms must have **four** bonds, and hydrogen only **one**.
- 4) The structures of the first three alkenes (ethene, propene and butene) are shown below:



As you can see from butene, the presence of the C=C bond means that most alkenes have **more than one** possible structure. The C=C bond can be in various different **positions** along the chain.

Molecules with the same **molecular formula** but different **structures** are called **isomers**.

The C=C bond does not allow the same **free rotation** and flexibility around itself as a C-C bond. It is a **rigid** bond. But the rest of the carbon chain is the same as in an alkane molecule, so rotation is allowed around the **single** bonds.

Properties of Alkenes

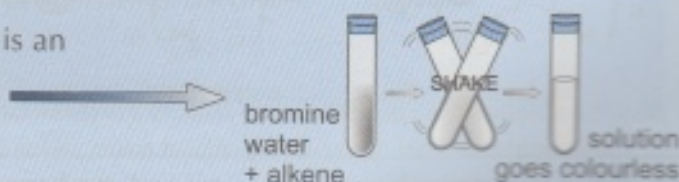
The presence of the C=C bond dictates the chemical properties of alkenes.

- 1) They are **reactive** compounds, undergoing many different types of chemical reaction.
- 2) They are used extensively to form **polymers**, e.g. poly(ethene) (see next page).
- 3) They **do not burn cleanly**, giving very **yellow** flames and lots of **soot**.

And as for alkanes, when you increase the **chain length** of an alkene:

- 4) The **boiling point** increases.
- 5) The **viscosity** increases.
- 6) The **volatility** decreases.

You can **test** for whether a compound is an alkene by adding it to **bromine water**. Alkenes **decolourise** bromine water, turning it from **orange** to **colourless**.



'Sleeping Butene' — coming soon to a cinema near you...

- 1) Draw out a structure for the next alkene: pentene (C₅H₁₀).
- 2) Draw out two alternative structures for hexene (C₆H₁₂).
- 3) Work out the general formula for the alkenes of the form C_nH_{2n}.

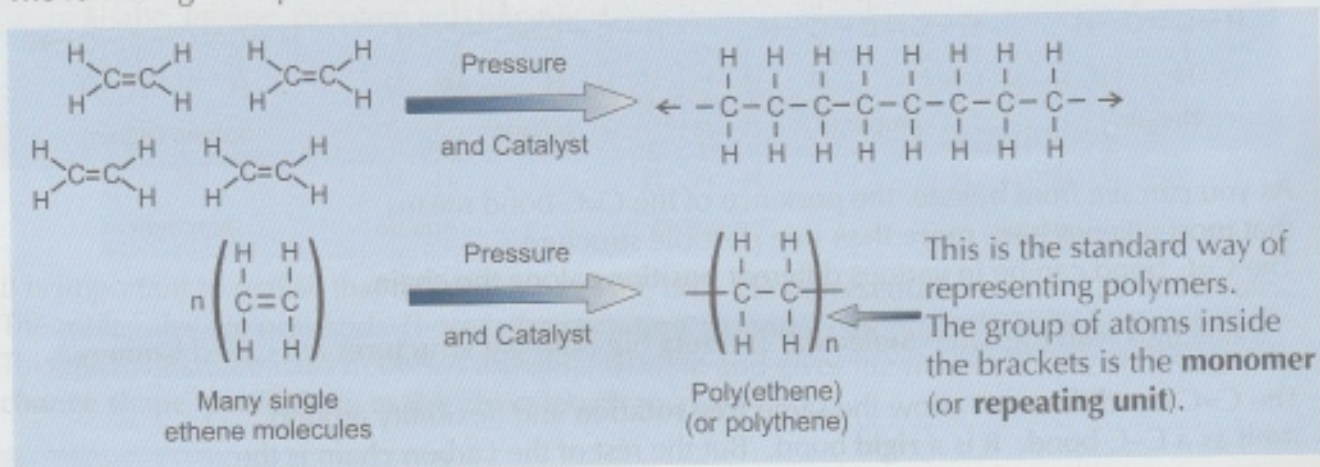
Polymerisation

Alkenes Can Form Polymers

The presence of the double bond in alkene molecules means that they are capable of forming **polymers**. A polymer is a long, chain-like molecule built up from lots of **repeating units**. In this case the repeating units, called **monomers**, are alkene molecules.

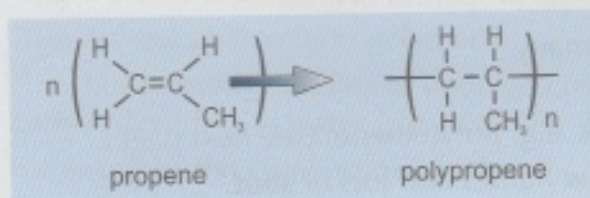
Under the right conditions (these depend on the alkene and the desired properties of the polymer), many small alkenes (like ethene and propene) will **open** up their double bonds and **link together** to form these long chain polymers.

The following example shows the formation of **poly(ethene)** (or **polythene** for short):



Other Small Alkenes do a Similar Thing

1) **Propene** polymerises to form **polypropene**.

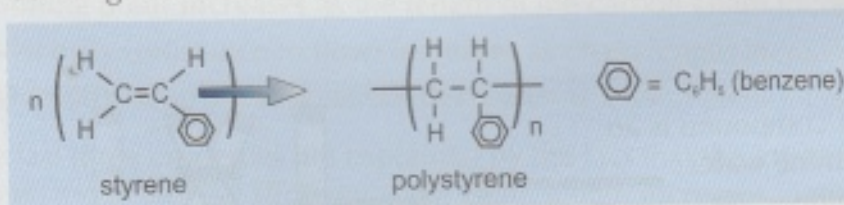


Pretty polymer.



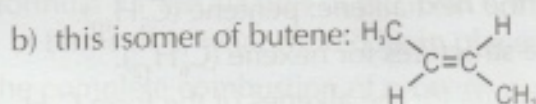
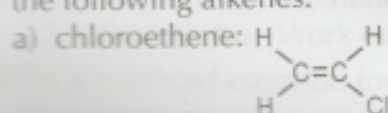
2) **Styrene**, which has a **benzene** ring in it, polymerises to form **polystyrene**.

(Benzene is just a ring of six carbon atoms in which the bonding electrons are shared between all six carbons.)



I'd go on and on about how great polymers are, but it'd get repetitive...

- 1) What property of alkenes allows them to form polymers?
- 2) Using the standard way of representing polymers, shown above, draw the polymers formed by the following alkenes:

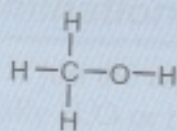


Alcohols

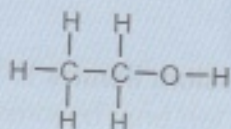
Alcohols Contain an -OH Group

The **alcohols** are a group of compounds that all contain an -OH group (an oxygen atom covalently bonded to a hydrogen atom).

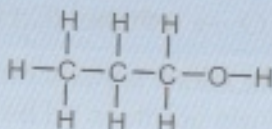
The first three alcohols are called **methanol**, **ethanol** and **propanol**. Their structures are:



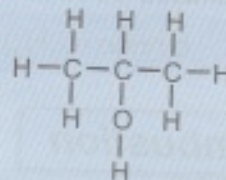
methanol



ethanol



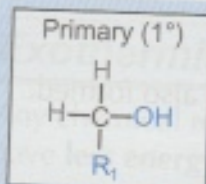
propanol



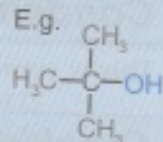
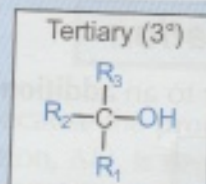
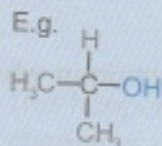
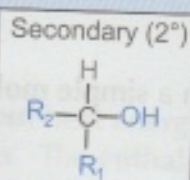
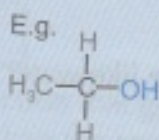
propanol again

For many alcohols, the -OH group can be put in different **positions** along the chain, so they are able to form **isomers** — just like in the example with propanol above.

Alcohols can be called **primary**, **secondary** or **tertiary**. The type of alcohol depends on what other groups surround the carbon atom that the -OH group is attached to.

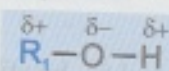


R = carbon chain



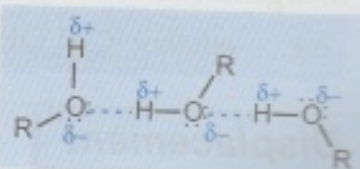
The Properties of Alcohols

Oxygen is an **electronegative** element (see page 10), so it draws the bonding electrons towards itself in the C-OH bond, meaning that alcohols are normally **polar** molecules.



The electronegative oxygen also draws electrons away from the **hydrogen atom** in the -OH group, giving the hydrogen atom a **slightly positive charge**. This charge attracts the **lone pairs of electrons** on oxygen atoms in other nearby alcohol molecules, which forms a **hydrogen bond** (page 10).

Hydrogen bonds have a big effect on the **properties** of alcohols.



- 1) Alcohols are **soluble** in water.
- 2) Alcohols have **high boiling** and **melting** points compared to alkanes or alkenes of a similar size. This is because hydrogen bonds are the **strongest** type of intermolecular bond, so they need lots of energy to break.

Alcohols — always wine-ing about their rum luck. I cava beer it...

- 1) Draw two different isomers of butanol, C₄H₉OH.
- 2) Work out the general formula of alcohols, using the form C_nH_{2n+1}OH.
- 3) Predict, with reasoning, whether ethane or ethanol will have a higher melting point.

