

## 2.5 – Hydrocarbons

### Fossil fuels

These are compounds derived from organisms that lived long ago that can be used as a source of energy.

#### Advantages

They are a variety of forms so that the type of fuel can be matched with its use and they are available at all times.

#### Disadvantages

They are non-renewable so cannot be reformed in a reasonable timescale.

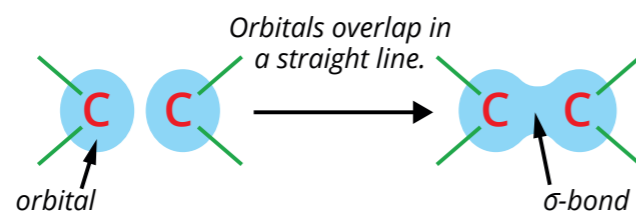
Combustion of fossil fuels produces CO<sub>2</sub> – a greenhouse gas that causes an increase in the Earth's temperature. If there is a shortage of oxygen, carbon monoxide, a toxic gas, is formed.

SO<sub>2</sub> and NO<sub>x</sub> can also be produced which react with water molecules in the air to produce H<sub>2</sub>SO<sub>4</sub> and HNO<sub>3</sub> – acid rain.

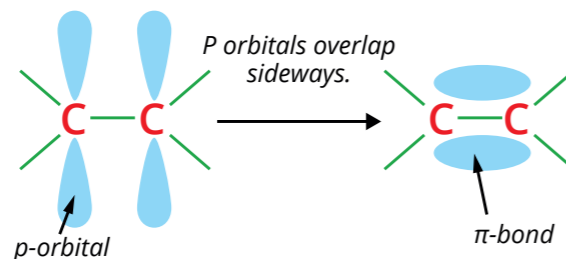
SO<sub>2</sub> and NO<sub>x</sub> also cause health problems for people with breathing difficulties.

### Alkenes

Alkenes have the general formula C<sub>n</sub>H<sub>2n</sub>. They have at least one C=C double bond so are unsaturated compounds. A double bond is made up of a sigma (σ-) bond and a pi (π-) bond. The σ-bond forms when two orbitals overlap end-on.



The π-bond is formed when two p orbitals overlap side-on, above and below the plane of the molecule.



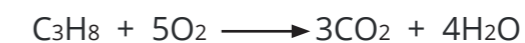
Because there are two pairs of electrons in the C=C double bond, it has a very high electron density. Due to this and the fact that π-bonds are weaker than σ-bonds, alkenes are much more reactive than alkanes.

### Alkanes

Alkanes have the general formula C<sub>n</sub>H<sub>2n+2</sub>. They are saturated hydrocarbons and are generally unreactive since they are non-polar and only contain sigma (σ-) covalent bonds. The σ-bonds involve end-on overlap of two orbitals which gives the highest electron density between the nuclei.

#### Reactions of alkanes

**Combustion** – alkanes burn in excess oxygen to produce carbon dioxide and water.



Since this reaction is exothermic alkanes are used as fuels.

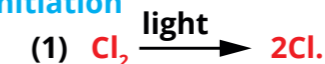
If insufficient oxygen is present, carbon monoxide or even carbon will form.

**Halogenation** – alkanes react with chlorine in uv light to form a halogenoalkane. The overall equation for the photochlorination of methane is

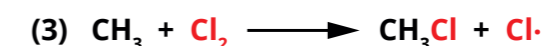
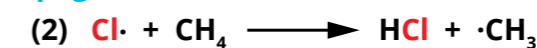


This is a (free) radical substitution and the mechanism has three stages.

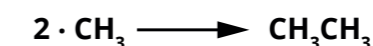
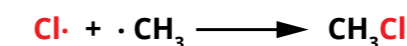
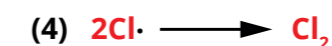
#### Initiation



#### Propagation



#### Termination

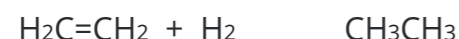


However, the reaction does not stop there, and propagation reactions happen again to form CH<sub>2</sub>Cl<sub>2</sub>, CHCl<sub>3</sub> and CCl<sub>4</sub>.

## 2.5 – Hydrocarbons

### Reactions of alkenes

**Hydrogenation** – Ethene reacts with hydrogen and a nickel catalyst at 150 °C to produce ethane.



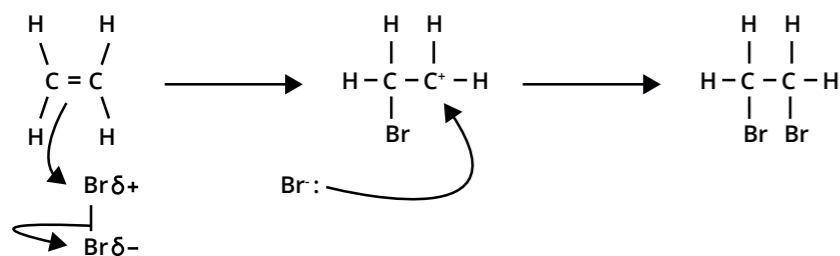
This is commercially important since unsaturated vegetable oils are reacted with hydrogen to form margarine.

**Electrophilic addition** – Halogens react with alkenes to form dihalogenoalkanes.



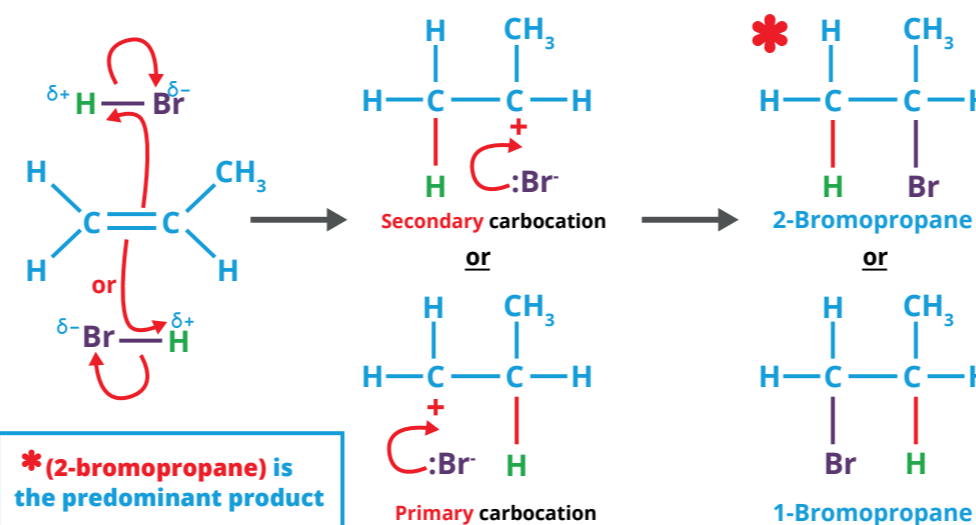
This is used as a test for alkenes, but bromine water is used instead of liquid bromine because bromine is corrosive. The orange solution goes colourless.

The mechanism involves the use of 'curly arrows'. A curly arrow shows the movement of a pair of electrons.



The high electron density of the C=C double bond induces a dipole in the Br—Br bond. The intermediate formed is a carbocation.

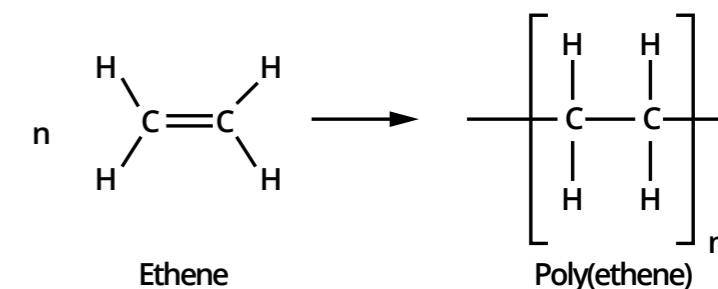
Hydrogen halides react with alkenes to form halogenoalkanes. Symmetrical alkenes, like ethene, will only produce one product. Unsymmetrical alkenes, like propene, will produce a major and minor product.



**\* (2-bromopropane) is the predominant product**

**because reaction proceeds via MORE STABLE SECONDARY CARBOCATION**

**Addition polymerisation** – The double bonds in alkenes and substituted alkenes (monomers) can open up and join together to form long chains called polymers.



Important polymers include poly(propene), poly(chloroethene) or PVC, poly(phenylethene) or polystyrene.

### E-Z isomerism

E-Z isomerism is an example of stereoisomerism, i.e. compounds that have the same structural formula but a different arrangement in space.

It occurs when the double-bonded carbon atoms each have two different atoms or groups attached to them because these groups can't rotate around the C=C double bond. (The p orbitals have to stay in the same position to overlap and form a π-bond.)

Each of the groups linked to the double-bonded carbons is given a priority; the higher the Ar/Mr the higher the priority. If the two carbon atoms have their 'higher priority groups' on the same side, it's a 'Z-isomer'. If they are on opposite sides, it's an 'E-isomer'.

