AQA Chemistry A-level

3.3.2: Alkanes

Detailed Notes

3.3.2.1 - Fractional Distillation

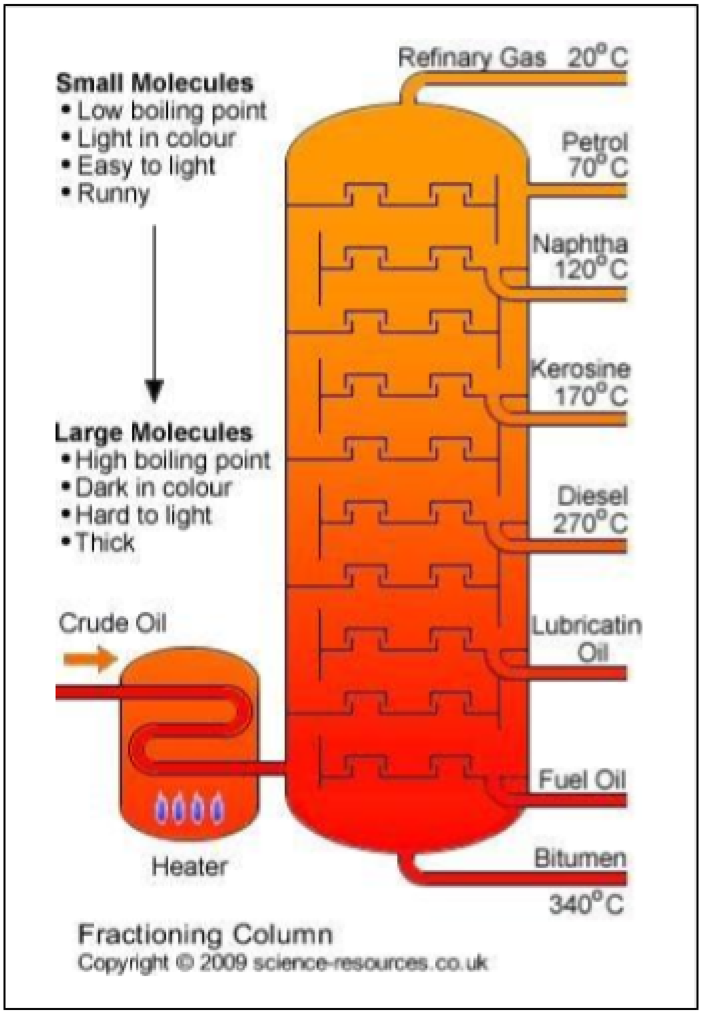
Crude oil is a mixture of different hydrocarbons. It can be separated into the separate molecules by **fractional distillation** as the different chain lengths of molecules result in them having **different boiling points**.

Crude oil is separated in the following way:

1. The mixture is **vapourised** and fed into the fractionating column.
2. Vapours **rise, cool** and **condense**.
3. Products are **siphoned off** for different uses.

Products with **short** carbon chains have **lower** boiling points, meaning they **rise higher** up the column before reaching their boiling point. Therefore they are **collected at the top** of the column.

Products with **long** carbon chains have **higher** boiling points, meaning they don't rise very far up the column before reaching their boiling point. They condense and are **collected at the bottom** of the fractionating column.



The compounds collected from the fractionating column are then **broken down further** via the method of **cracking**.

3.3.2.2 - Cracking

Longer carbon chains are not very useful, therefore they are broken down to form **smaller, more useful molecules**. The carbon-carbon bonds are broken in order to do this, which require quite **harsh reaction conditions**. There are two main types of cracking which result in slightly different organic compounds.

Thermal Cracking

This method produces a high proportion of **alkanes and alkenes**. High temperatures around **1200 K** and pressures around **7000 kPa** are used to crack the carbon chains.

Catalytic Cracking

This method produces **aromatic compounds** with carbon rings. Lower temperatures around **720 K** are used along with normal pressure, but a **zeolite catalyst** is needed to compensate for these less harsh conditions.

3.3.2.3 - Combustion of Alkanes

Alkanes make good fuels as they **release a lot of energy** when burned. With sufficient oxygen present, they undergo **complete combustion** to produce carbon dioxide and water.

Example:

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

If the oxygen present is insufficient, combustion is **incomplete** and **carbon monoxide** is produced alongside water.

Example:

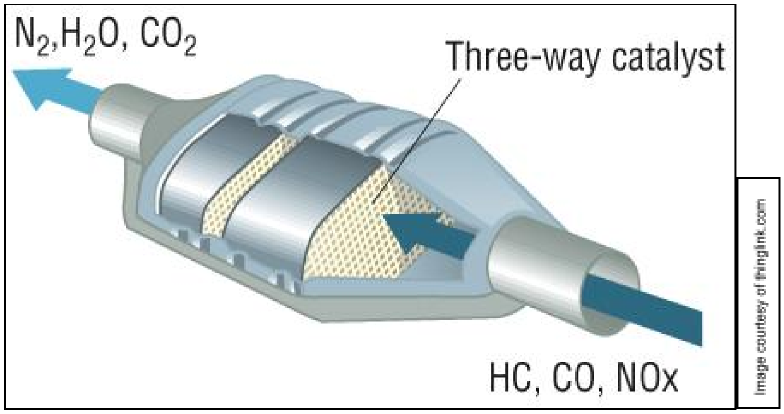
$$2CH_4 + 3O_2 \longrightarrow 2CO + 4H_2O$$

Catalytic Converters

Carbon monoxide is a **toxic** gaseous product which is especially dangerous to humans as it has no odor or colour. Oxides of nitrogen are also produced as a byproduct of alkane combustion.

Both of these gaseous products can be removed from systems using a **catalytic converter.** This uses a **rhodium catalyst** to convert harmful products into more stable products such as CO_2 or H_2O.

Example:



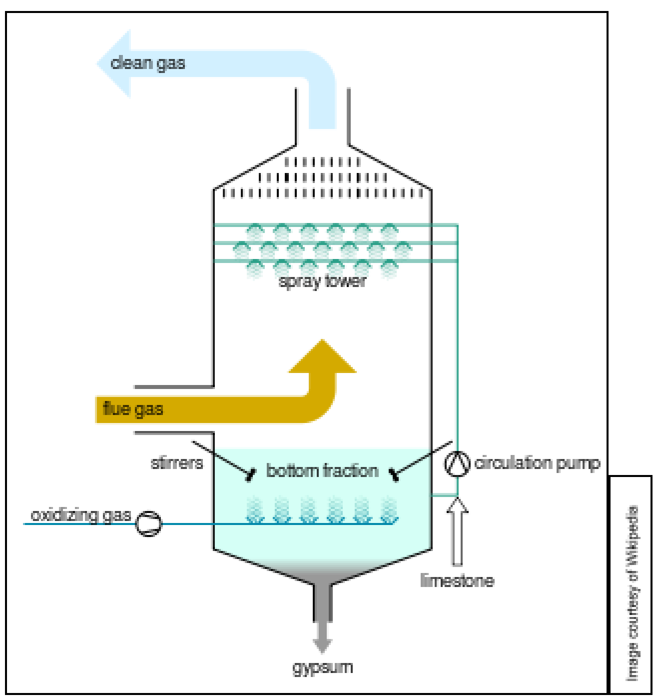
Carbon Particulates

Incomplete combustion can also produce **carbon particulates**, small fragments of unburned hydrocarbon. Unless removed from the waste products in industry, these can cause serious **respiratory problems** as they pollute the air.

Flue Gas Desulfurisation

Sulfur impurities can lead to the **acidification of water** in the Earth's atmosphere as they react to form a weak form of H_2SO_4. The impurities can be removed from waste products via **flue gas desulfurisation**. **Calcium oxide and gypsum** are used in this process.

Example:



Unless treated or removed, all of these pollutants can contribute to **global warming, acid rain** and **health issues** in humans.

3.3.2.4 - Chlorination of Alkanes

Alkanes react with halogens in the presence of **UV light** to produce halogenoalkanes. The UV light breaks down the halogen bonds producing reactive intermediates called **free radicals**. These attack the alkanes resulting in a series of reactions; **initiation, propagation and termination**.

Example:

1. **Initiation** - the halogen is broken down.

$$Cl_2 \xrightarrow{UV} 2Cl\bullet$$

Free radicals are shown using a dot.

2. **Propagation** - a hydrogen is replaced and the Cl• radical reformed as a catalyst

$$Cl\bullet + CH_4 \longrightarrow \bullet CH_3 + HCl$$

$$\bullet CH_3 + Cl_2 \longrightarrow CH_3Cl + Cl\bullet$$

3. **Termination** - two radicals join to end the chain reaction and form a stable product.

$$\bullet CH_3 + \bullet CH_3 \longrightarrow C_2H_6$$

The propagation step can continue many times to result in **multiple substitutions**, this is a **chain reaction**. Condition of the reaction can be altered to favour the termination step and limit the number of substitutions.