

ALKANES

GENERAL FORMULA

The general formula of alkanes is



FRACTIONAL DISTILLATION

HYDROCARBONS

Alkanes are hydrocarbons, because they are made up of only carbon and hydrogen atoms.

SATURATED

Alkanes are saturated because their carbon-carbon bonds are all single bonds (unlike alkenes, which also have C=C bonds).

FRACTIONAL DISTILLATION

Petroleum is used as a fuel for cars. It is obtained from crude oil, which is a mixture containing mostly alkanes, ranging in length from one carbon (methane) to over 100 carbons.

As these alkanes have different boiling points, they can be separated using fractional distillation.

- Crude oil enters the bottom of the fractional distillation column and boils.
- Higher in the column, the temperature is lower.
- Alkanes of different lengths condense at different points in the column, depending on their **boiling points**.
- Shorter alkanes have lower boiling points and condense higher in the column.
- Several **fractions** are obtained, which are mixtures of alkanes with chains of a similar length.
- Fractional distillation may be repeated to separate these further.

Petroleum contains alkanes between 5 and 10 carbons in length.

CRACKING

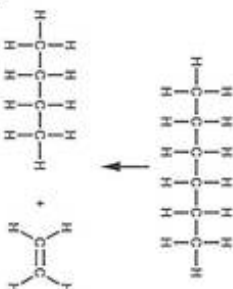
CRACKING

Cracking is the process of breaking alkanes into shorter-chain alkanes and alkenes. Carbon-carbon bonds are broken in the process.

ECONOMIC REASONS FOR CRACKING

1. There is less demand for long alkanes.
2. Shorter alkanes are useful for fuels, which are in high demand and, therefore, more profitable.
3. The alkenes can be used to synthesise larger molecules such as polymers or pharmaceuticals.

EXAMPLE



THERMAL AND CATALYTIC CRACKING

There are two main ways of performing cracking: thermal cracking and catalytic cracking.

	Thermal	Catalytic
Conditions	• High temperature • High pressure • No catalyst	• High temperature • Slight pressure • Zeolite catalyst
Products	High percentage of alkenes	High percentage of aromatic hydrocarbons used as motor fuels

COMBUSTION

Alkanes are often used as fuels, and so combustion is an important reaction of alkanes.

COMPLETE COMBUSTION

The complete combustion of alkanes forms CO_2 and H_2O only.



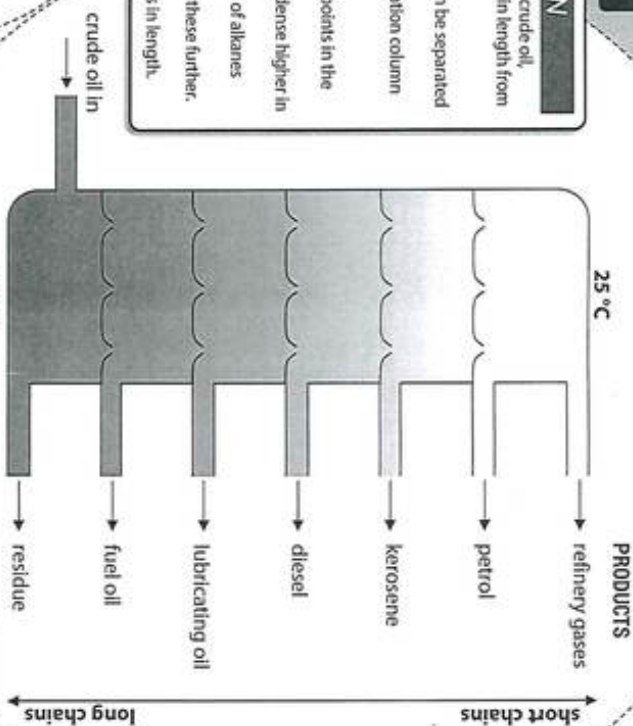
INCOMPLETE COMBUSTION

When there is not enough oxygen, incomplete combustion can also occur:



Carbon monoxide, CO , or carbon, C , are produced instead of CO_2 .

Carbon monoxide is an odourless, tasteless and invisible gas which is highly toxic. It is very dangerous and hard to detect.



CHLORINATION OF ALKANES

RADICAL SUBSTITUTION

Alkanes react with halogen radicals to form haloalkanes.

INITIATION

Chlorine radicals are produced by UV light via homolytic fission.



PROPAGATION



These two steps are a cycle which produces the products HCl and $\text{C}_6\text{H}_{13}\text{Cl}$, and regenerates $Cl\cdot$. $Cl\cdot$ can react thousands of times over in a **chain reaction**.

TERMINATION

Termination steps form a non-radical from two radicals.



The $\text{C}_6\text{H}_{13}\text{Cl}$ can then react further with another $Cl\cdot$, generating $\text{C}_6\text{H}_{12}\text{Cl}_2$, and then further substituted products. The substitution can also occur at any point on the chain.

Because many different products can be formed, radical substitution is not a very useful reaction for synthesising a pure compound.

INTERNAL COMBUSTION ENGINE

SULFUR DIOXIDE

Fuels containing sulfur form SO_2 when burned. This reacts with rainwater to form acid rain.

It is removed from factory chimneys by lining the chimney with a base to neutralise acidic SO_2 . For example:



POLLUTANTS

When alkane fuels are burned, pollutants are formed, including:

1. **nitrous oxides** (NO_x) – cause respiratory problems
2. **carbon monoxide** (CO) – poisonous
3. **carbon** – forms soot
4. **unburned hydrocarbons** – cause respiratory problems

To minimise the effects of pollutants from internal combustion engines, they are reacted in a catalytic converter. For example:

