

Alkanes & Halogenoalkanes knowledge organiser

Size chain	Short	Long
Boiling point	Low	High
Flammability	High - Ignites easily	Low - Hard to ignite
Viscosity	High - Flows easily	Low - Doesn't flow well

1. Properties

General formula: C_nH_{2n+2}

Properties of the alkanes, summarised to the left, are linked to the length of their chains. Between these simple molecules there are weak intermolecular forces of attraction which increase with the chain length. Alkanes are fairly unreactive but good combustibles.

2. Fractional distillation

In fractional distillation:

- crude oil heated to about 370°C and fed into the bottom of a fractionating column, hottest at bottom, coolest at top.
- the vapours pass up the tower via a series of trays containing caps until they reach a tray that is cold enough to allow their condensation depending on boiling point.
- at each level the fraction is piped off.
- lighter smaller chains rise, cool and condense at the top
- heavier longer chain fractions are collected at the bottom

Large chain fractions are cracked producing smaller more useful fuels.

3. Cracking

Cracking – breaks long chain hydrocarbons into shorter chain hydrocarbons

Thermal cracking

Conditions high temperature (700-1200°K) and high pressure 7000Pa.

C-C bonds break forming 2 radicals that form a variety of shorter chains molecules. High proportions of alkanes are produced.

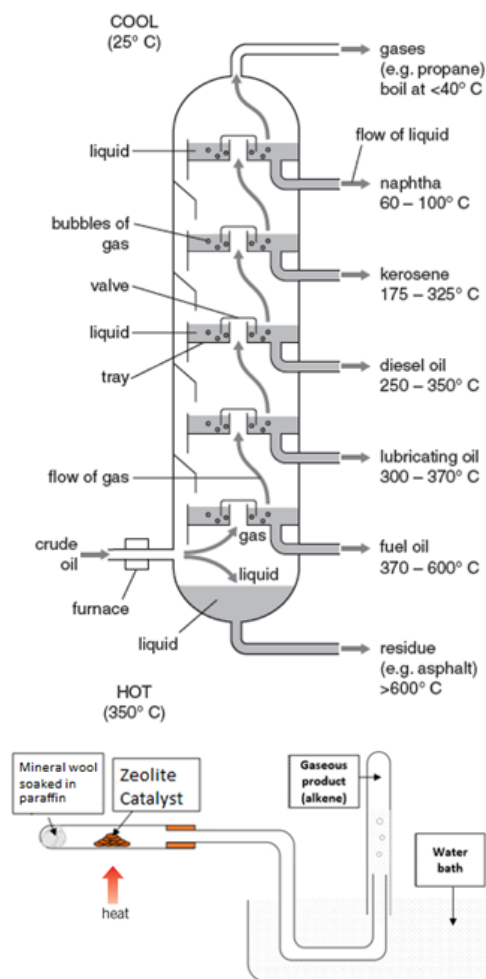
Catalytic cracking

Conditions 720°K, pressure just above atmospheric and Zeolite catalyst. Makes branched alkanes, cycloalkanes and aromatic compounds.

4. Combustion

Complete combustion (plenty of oxygen) of alkanes produces carbon dioxide and water only, releasing large amounts of energy.

Incomplete combustion (limited supply of oxygen) of alkanes produces carbon monoxide and water, with even less oxygen carbon (soot) is produced. This often happens with long hydrocarbons that need a lot of oxygen. Less energy is released.



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1. Pollution

Combustion of all hydrocarbons may produce polluting products when burnt such as:

- Carbon monoxide (CO): a poison
- Nitrogen oxides (NO_x): formed in the engine thanks to the high temperatures. These gasses can react with water to form nitric acid arising acid rain and photochemical smog.

$$\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}(\text{g})$$
- Sulphur dioxide (SO₂): produced by sulphur impurities in fuel. This gas can react with water to form sulphuric acid arising acid rain.

$$\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$$

$$\text{SO}_2(\text{s}) + 0.5\text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$$
- Carbon particles, called particulates, which can cause cancer and asthma.
- Unburnt hydrocarbons may enter the atmosphere that contribute to photochemical smog and are green house gasses. •Carbon dioxide (CO₂): a green house gas.
- Water vapour (H₂O): a green house gas.

2. Desulfurisation

The gas given out by power stations are called flue gases so the process of removing sulphur dioxide is called flue gas desulfurisation.

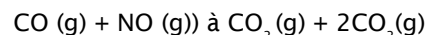
- In one method a slurry of calcium oxide (lime) and water is sprayed into the flue gas to form gypsum (calcium sulphate) that can be used to make plaster and plasterboards:

$$\text{CaO}(\text{s}) + \text{SO}_2(\text{s}) + 0.5\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$$
- In an alternative process calcium carbonate (limestone) is used instead of calcium oxide:

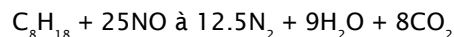
$$\text{CaCO}_3(\text{s}) + \text{SO}_2(\text{s}) + 0.5\text{O}_2(\text{g}) \rightarrow \text{CaSO}_4 + \text{CO}_2(\text{g})$$

3. Catalytic converter

The catalytic converters is a honeycomb made of ceramic coated with platinum and rhodium metals that work as catalysts. The structure allows for a high surface area to catalyse:

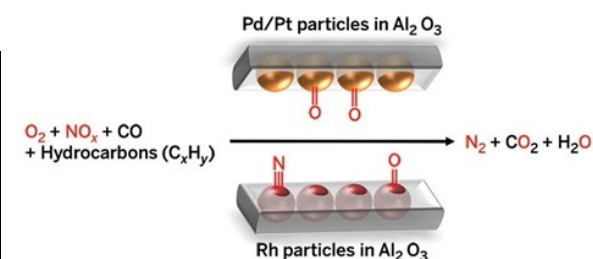
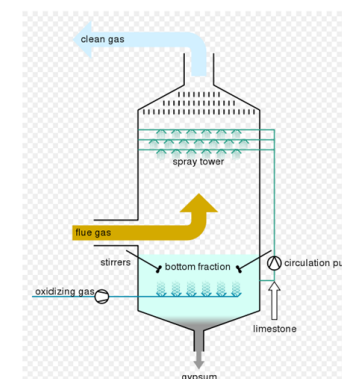
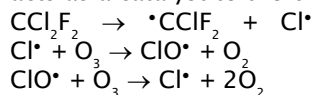


And this reaction with unburned hydrocarbons (this reaction can be adapted to any hydrocarbon):



4. CFCs

Chlorofluorocarbons (CFCs) can be damaging for the Ozone layer due to a free radical mechanism reaction where chlorine acts as a catalyst to the breakdown of ozone into oxygen. (more details about free radicals in section 4)



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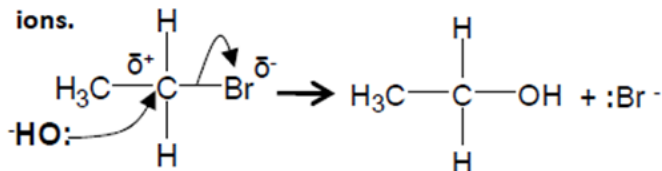
1. Keywords

Anhydrous	In the absence of water
Initiation:	Radical forming step.
Nucleophile:	Electron pair donor.
Propagation:	Spreading of the radicals.
Radical:	Free radicals are reactive species with an unpaired electron and are drawn using a dot.
Termination:	All radicals are removed.

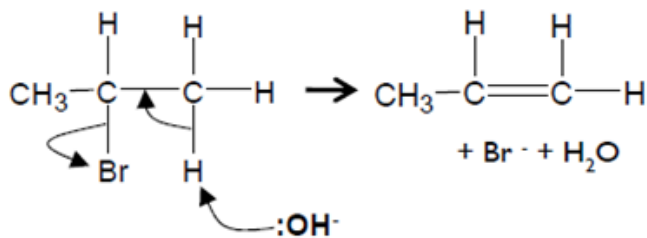
4 Chemical reactions

Halogenoalkanes undergo Nucleophilic substitution in the presence of a nucleophile with the halogens as the leaving group. Or elimination reaction in hot anhydrous, usually ethanolic, conditions.

Nucleophilic Substitution of Halogenoalkanes with aqueous hydroxide ions.



Elimination of Halogenoalkanes with ethanolic hydroxide ions



2. Properties

General formula $C_nH_{2n+1}X$ where X is the halogen

Halogenoalkanes can be classified into:

- Primary have one R group attached to the carbon linked to the halogen.
- Secondary have two R groups attached to the carbon linked to the halogen.
- Tertiary have three R groups attached to the carbon linked to the halogen.

Physical properties of halogenoalkanes mainly depend on the polarity of the C-X bond.

- Solubility: the polarity of the bond is not enough to make halogenoalkanes soluble in water, the main intermolecular forces are Van der Waals and dipole-dipole attractions.
- Boiling point: - increases with increased chain length.
- increases going down the halogen group.

Chemical properties depend on the C-X bond strength and polarity. Reactivity increases going down the halogen group even though C-I is the least polar bond, this is due to atom size.

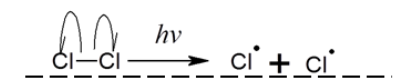
3 Formation

Halogenoalkanes are formed via different mechanisms.

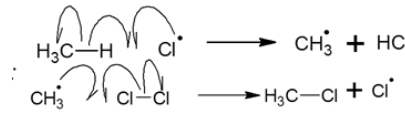
Free radical substitution reaction starting from an alkane and a halogen, this reaction occurs only in the presence of UV light.

$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$ this reaction occurs in 3 steps:

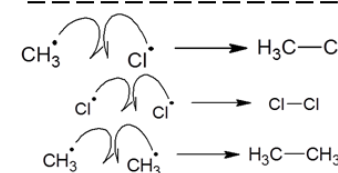
1. Initiation: breaking of the covalent bond of the halogen. Highly reactive free radicals are formed.



2. Propagation: the free radical takes the hydrogen on the alkane to form an alkyl radical and a new alkyl radical is formed. The new radical reacts with another halogen producing a halogenoalkane and another halogen radical.



3. Termination: in this step free radicals react with each other. All radicals are removed.



Other products are formed.

From alkenes with hydrogen halides at room temperature or from alkenes reacting with halogens.

