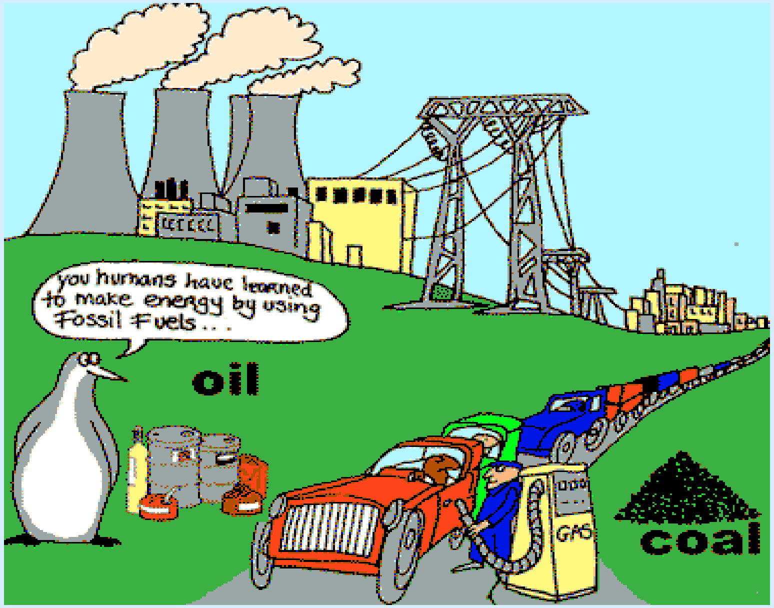
Hydrocarbons and Fuels

Alkanes, Alkenes, and Alkynes, Halogen derivatives, Aromatic hydrocarbons, Petrol, Alternative fuels,



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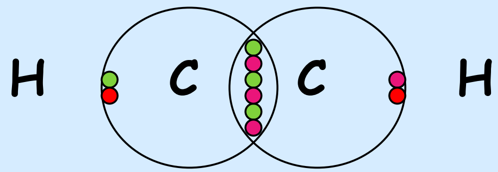
Organic Chemistry

Originally, chemical compounds were divided into 2 classes: Inorganic or Organic

Organic compounds were derived from living things. It was believed that they contained a 'vital force' and could not be made from inorganic compounds (non-living sources).

Carbon has the ability to CATENATE, forming covalent bonds with its own atoms. This allows for the formation of many millions of carbon compounds



Ethene, C_2H_4

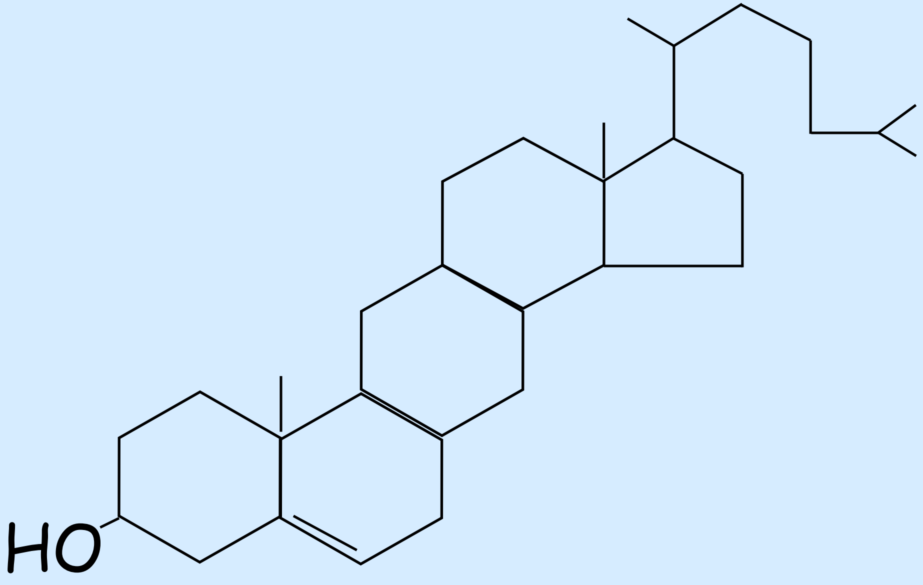
Organic Chemistry

Organic chemistry is basically the study of compounds containing carbon (*with the exclusion of oxides and carbonates*).

There are so many compounds containing carbon that a whole branch of chemistry is devoted to their study.

Organic molecules may be as simple as methane, CH_4

or as complicated as cholesterol



Homologous series

A homologous series are a family of organic compounds with the same general formula. They have a common functional group.
Examples of homologous groups include:

Homologous series	**General formula**	**Functional group**
Alkanes	C_nH_{2n+2}	
Alkenes	C_nH_{2n}	C=C
Alkynes	C_nH_{2n-2}	C≡C
Alkanols	C_nH_{2n+1} OH	R – OH
Alkanoic acids	C_nH_{2n+1} COOH	R – COOH
Alkanals	C_nH_{2n+1} CHO	R – CHO

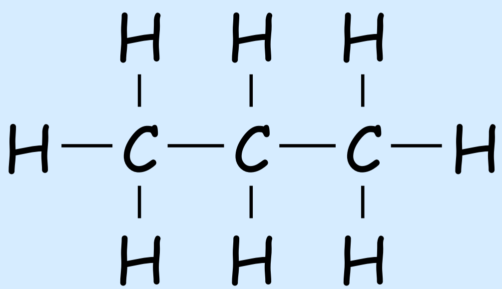
Alkanes and Alkenes

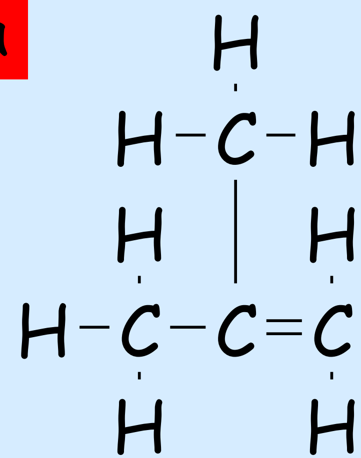
Alkane general formula C_nH_{2n+2}

Alkene general formula C_nH_{2n}

Name	No C's
Meth	**1**
Eth	**2**
Prop	**3**
But	**4**
Pent	**5**
Hex	**6**
Hept	**7**
Oct	**8**

Structural formula





Straight Chain

Branched chains and unsaturated C=C bond

$CH_3CH_2CH_3$ $CH_3(CH_2)_2CH_3$ $CH_3CH_2CH_2CH_3$

Condensed formula

Molecular formula C_4H_9

Naming Compounds of Carbon

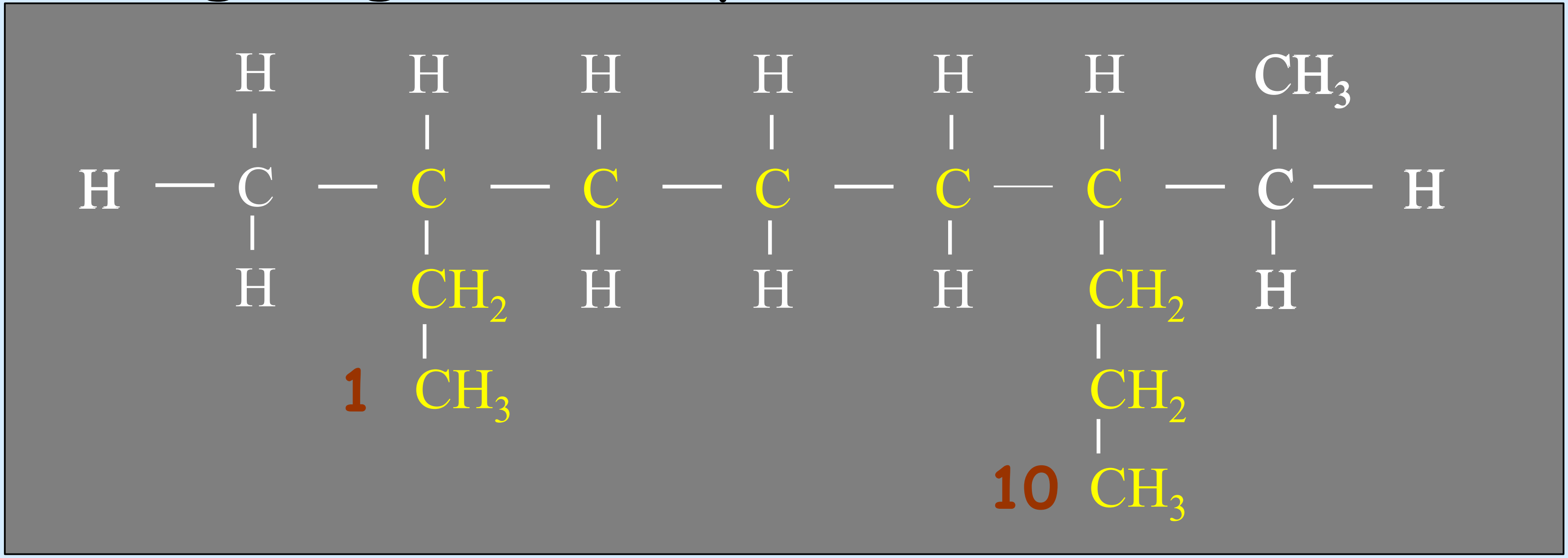
Alkanes

1. Identify the longest chain
2. Identify the 'branches' and name them.
3. Number the carbon atoms on the longest chain, at the end giving the **lowest numbers** for the branches.
4. Write the branches in alphabetical order.
5. If there are more branches with the same name use di, tri etc

Alkenes

1. Identify the longest chain, that contains a double bond.
2. Identify the 'branches' and name them.
3. Number the carbon atoms on the longest chain, starting from the end **nearest the double bond**. Pick the lowest number to describe the position of the double bond.
4. Write the branches in alphabetical order.
5. If there are more branches with the same name use di, tri etc

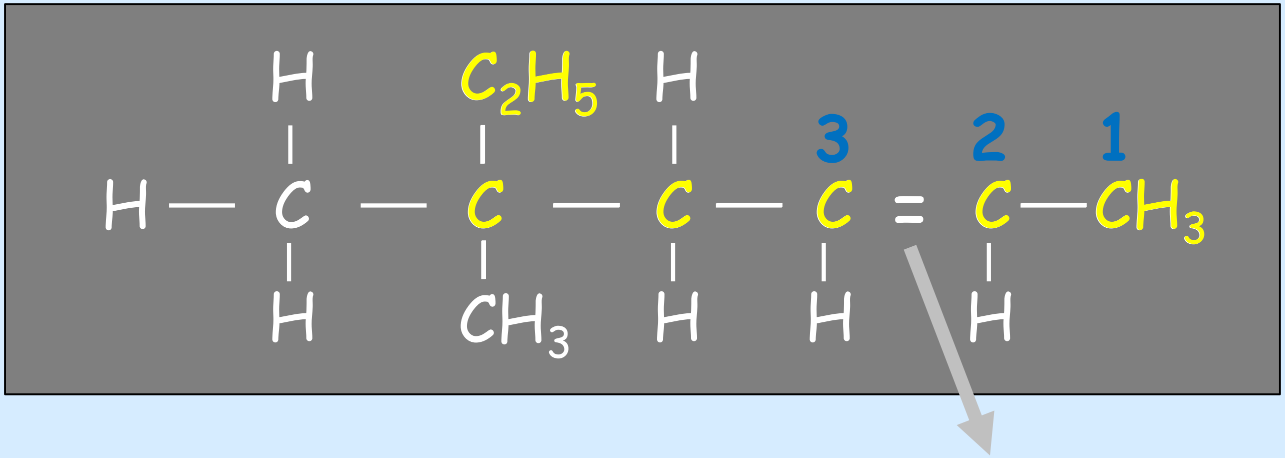
Naming Organic Compounds, Alkanes



1. Decide on the type of compound (ie. consider functional group) **alkane**

2. Select the longest chain. **10 C's ∴ decane**

3. Name the compound with the branched chains in alphabetical order. **7-ethyl-3-methyldecane**



1. Decide on the type of compound (ie. consider functional group)

alkene

2. Select the longest chain

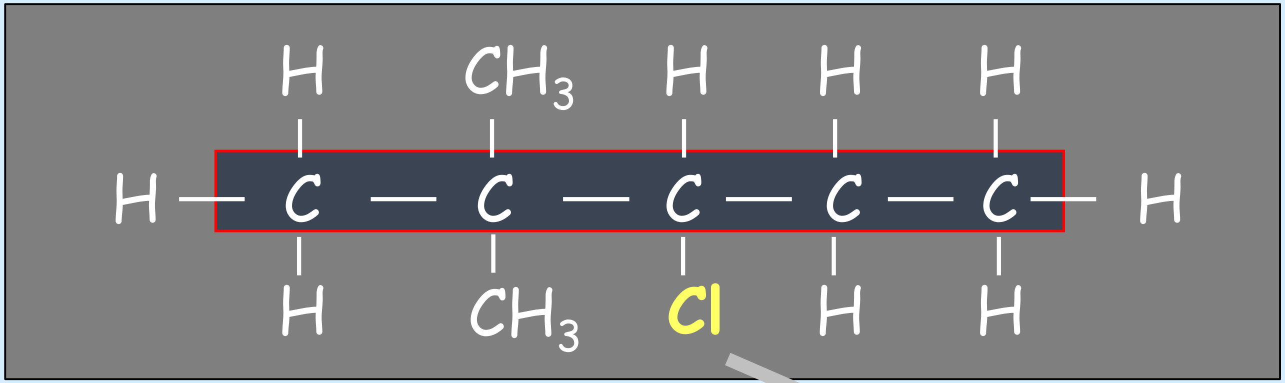
7 C's ∴ heptene

3. Number the C atoms so that the functional group has the lowest number

hept-2-ene

4. Name the compound with the branched chains in ascending order.

5,5-dimethylhept-2-ene



1. Decide on the type of compound (ie. consider functional group)

halogen (chloroalkane)

2. Select the longest chain

5 C's ∴ pentane

3. Name the compound with the branched chains and halogen in alphabetical order.

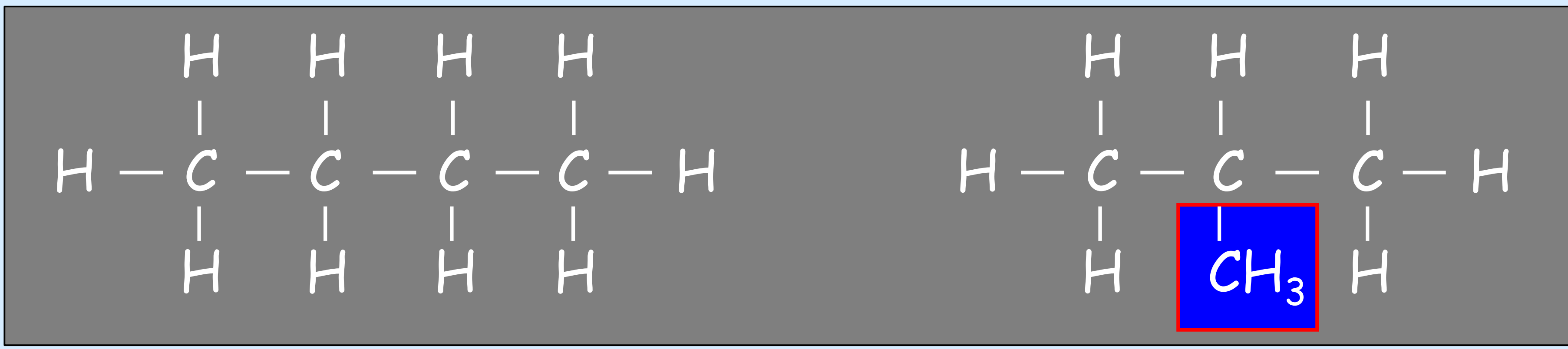
3-chloro-2,2-dimethylpentane

Structural Isomers

There are two types

1. **Chain isomerism.**

Here the isomers have different arrangements of carbon atoms or different chains. For example there are two compounds with the molecular formula C_4H_{10}

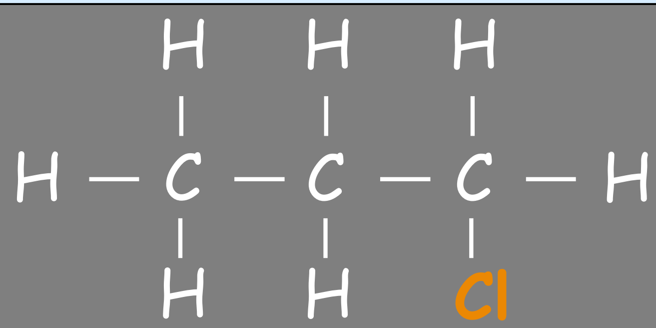


butane　　　　　　　　　　2-methylpropane

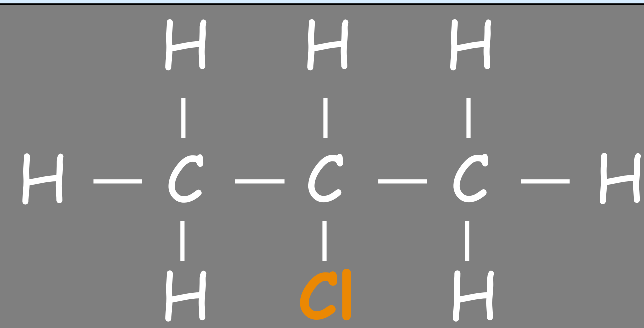
Here, you can see that 2-methylpropane has a side chain.

2. Position Isomerism.

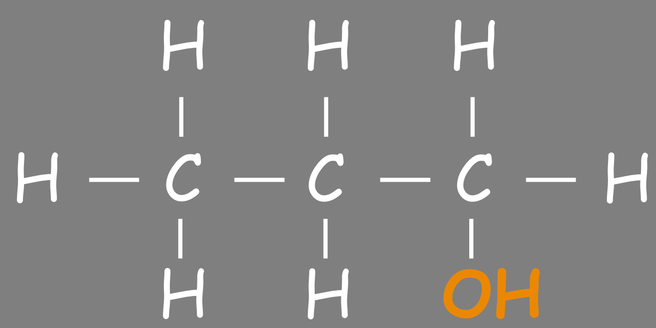
Here the isomers have the same carbon skeleton and functional group but the position of the functional group is different.



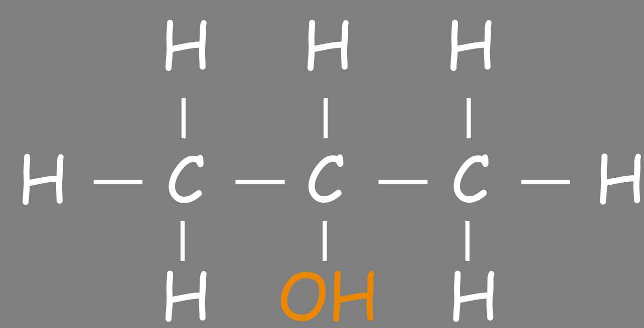
1-chloropropane



2-chloropropane



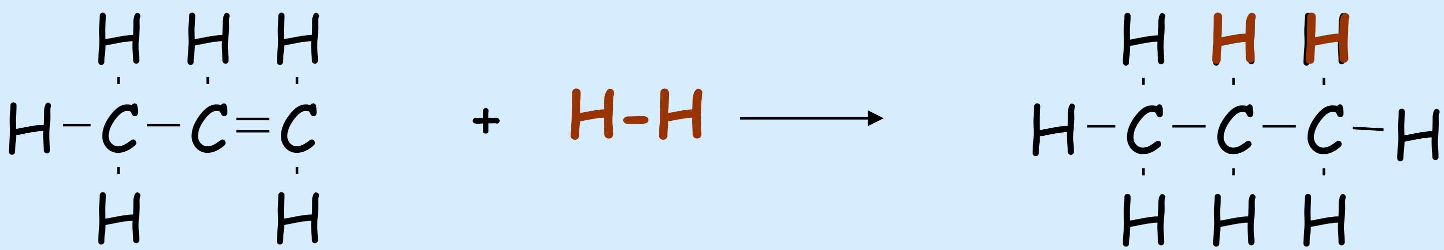
propan-1-ol



propan-2-ol

Reaction of Alkenes

Hydrogenation, the reaction of propene with hydrogen is an **example of an** addition reaction.



Propene **Propane**

Reaction with halogens is another example of an addition reaction

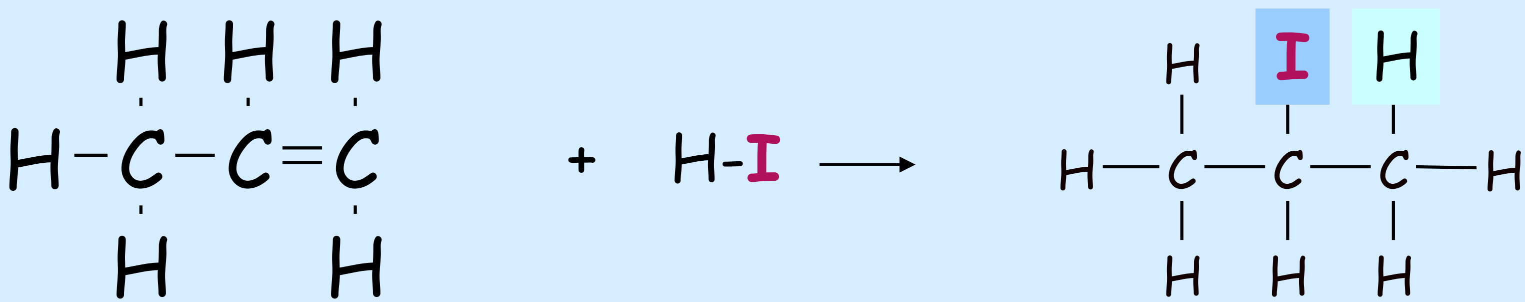
1,2-dibromopropane

colourless

This can be used for a test for C=C bond

Reaction of Alkenes

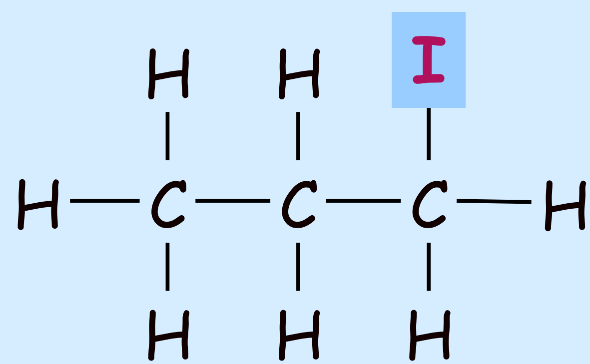
Reaction with **Hydrogen Halides**



2 -iodopropane

Normally the H from the halide attaches to the C which already has the most hydrogen's.

or



1 -iodopropane

Alkenes with water

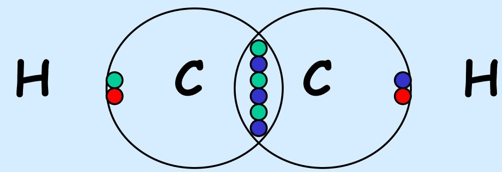
Concentrated sulphuric acid reacts with ethene in the cold. The reaction is an example of Hydration.
The overall effect of the acid is to combine water with ethene.
At one time, this was the most important method for manufacturing ethanol from ethene. Nowadays, direct catalytic hydration of ethene is used.

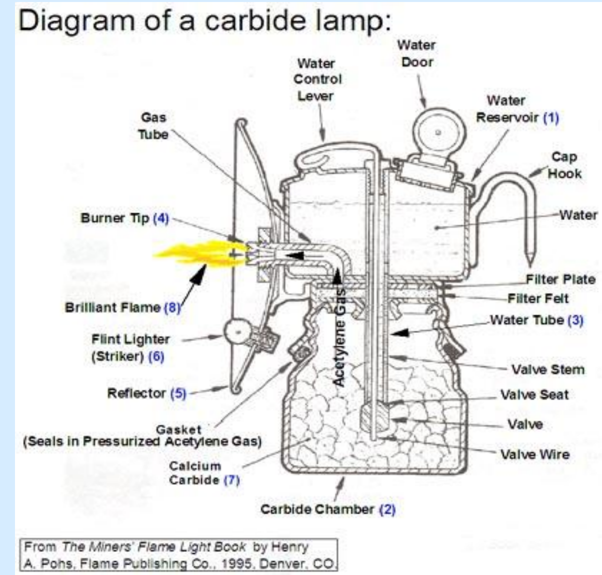
$$CH_2 = CH_2 + H_2O \xrightarrow{\text{Conc } H_2SO_4} CH_3CH_2OH$$

Alkynes C_nH_{2n-2}

Ethyne

C_2H_2 $H \cdot C \equiv C \cdot H$





$CaC_2 + 2\,H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

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Addition reactions with H_2, hydrogen halides and halogens are similar to alkenes, but two stages are possible

Ethyne Ni Catalyst 150 °C

1st $H - C \equiv C - H + H_2 \longrightarrow$ Ethene

2nd $H - \underset{\underset{H}{|}}{C} = \underset{\underset{H}{|}}{C} - H + H_2 \longrightarrow$ Ethane

Ethene

Halogen Derivatives (Haloalkanes)

Halogenalkanes and halogenalkenes

$CHCl_3$	Chloroform	$CCl_2=CCl_2$	Solvent for grease
CCl_2F_2	Freon	CCl_4	Degreasing agent
CH_3CCl_3	Correcting fluid	CCl_2H_2	Paint Stripper
$CF_2=CF_2$	Gortex, Teflon	$CH_2=CHCl$	Vinyl chloride

2-bromo-2-chloro-1,1,1-trifluorethane Halothane

Lava lamps, non-polar alkanes and chloroalkanes mixed with polar water.

Halogen Derivatives, CFC's

Chlorofluorocarbons CFC's

All CFC's are very unreactive, are not flammable and not toxic. They are used as flame retardants.

CCl_2F_2 The first refrigerant, and in aerosols.

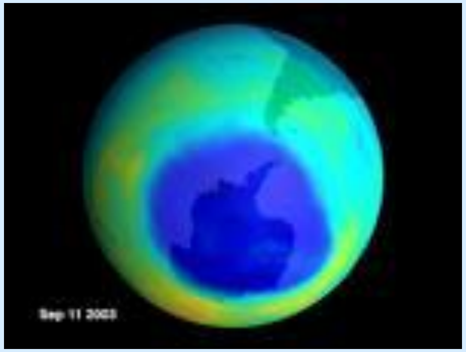
CCl_3F Used as a blowing agent to make expanded foam

Recently hydrofluorocarbons have replaced some CFC's.

e.g. 1,1,1,2-tetrafluoroethane is used as a refrigerant.

Ozone destruction O_3

Chlorofluorocarbons CFC's



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$$CCl_3F \xrightarrow{\text{U.V.light}} CCl_2F\bullet + Cl\bullet$$

$$Cl\bullet + O_3 \longrightarrow ClO + O_2$$

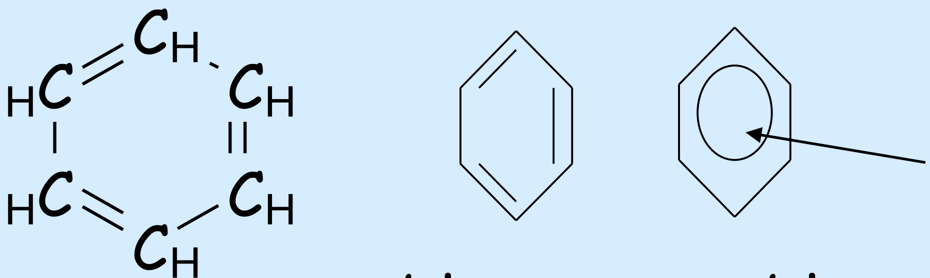
$$ClO + O \longrightarrow Cl\bullet + O_2$$

CFC's are very stable, lasting for 100 years in the atmosphere. So over time, CFC's can reach the stratosphere. Here, UV radiation attacks the CFC's forming free radicals ($\bullet$) .

Free radicals react with O_3, the reaction is complex, but one Cl free radical can catalyse the break down 1 million O_3 molecules.

Aromatic Hydrocarbons

C_6H_6 Benzene is the simplest member of the class of aromatic hydrocarbons



unstable stable

The electrons delocalise to form a stable structure.

Aromatic carbon molecules contain the benzene ring.

The benzene ring does not contain 3 double bonds, and so does not take part easily in addition reactions.
It is insoluble in water, being non-polar.
It burns with a smoky flame as carbon is produced.

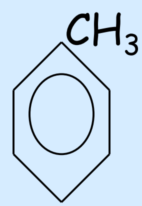
F.A. Kekule proposed the original structure as a result of a dream

Aromatic compounds

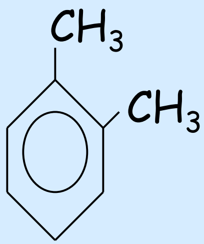
Aromatic compounds are important feedstocks and are used in dyes, herbicides, insecticides fungicides.

One or more hydrogen atoms of benzene molecule can be subsituted to form a range of consumer products.

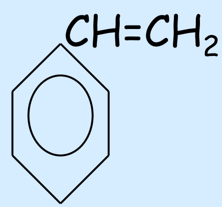
Methylbenzene (toluene)
Used for solvents and making benzoic acid



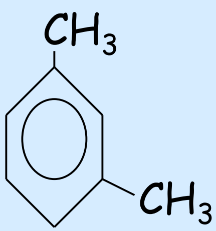
1,2 – dimethylbenzene
Used to make dyes and insecticides



Phenylethene (styrene)
$C_6H_5CH_2CH$
Used to make many polymers



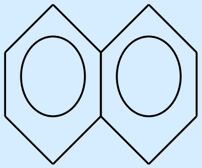
1,3 – dimethylbenzene
Used to make polymers, as a solvent and cleaning steel

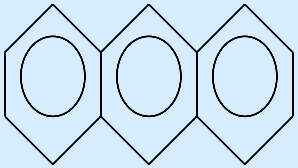


Aromatic compounds

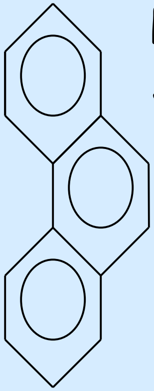
Poly-aromatic hydrocarbons PAH

Naphthalene
Mothballs

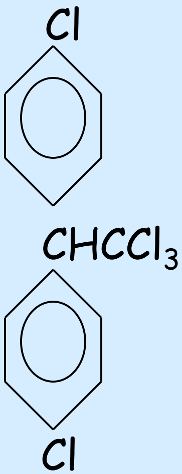




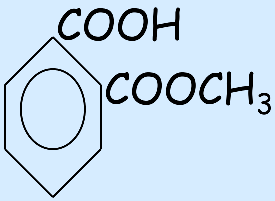
Anthracene
Dyes and persevatives



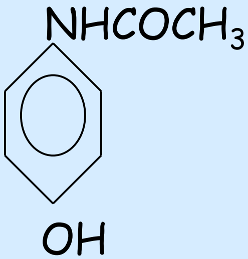
Phenanthrene
Steroids



DDT
dichlorodiphenyl
trichloroethane



Aspirin
2-ethanoyloxybenzenecarboxcyclic acid



Paracetamol
4-hydroxyphenylethanamide

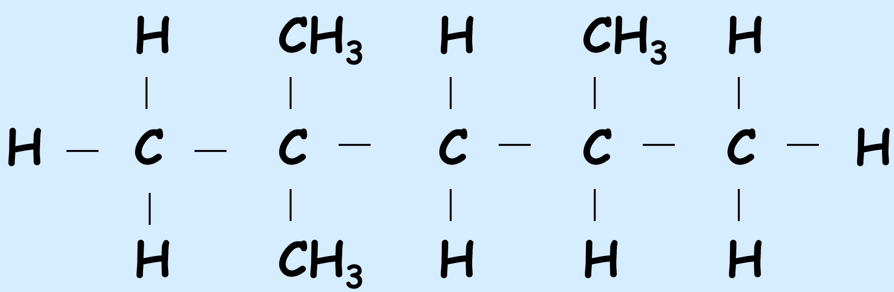
Petrol

By products from the combustion of petrol are CO, CO_2, NO_x and unburned Hydrocarbons

Long chain Hydrocarbons tend to burn unevenly in a car engine, causing 'knocking'. Branched chained hydrocarbons burn more evenly, so prevent 'knocking'.

In the past in the UK, lead compounds added to petrol, to prevent this.

The alkane 2,2,4,-trimethylpentane has good antiknock properties.



This also has a high octane rating, 100. Straight chain hydrocarbons have a lower octane rating, heptane has an octane number of 0. Benzene is 106. Unleaded petrol in UK has octane rating of 95.

Petrol

Reforming, is the process by which straight-chain alkanes undergo a chemical change , which results in new, smoother burning compounds. High temperatures, pressures and a catalyst are used. Platinum is often used in a process called 'Platforming'

Branched-alkanes, cycloalkanes and aromatic compounds are produced.

Hydrocracking, takes place at high temperatures in the presence of hydrogen. Long straight chain hydrocarbons are changed into small branched chain and straight chain alkanes.

Petrol is a blend of different hydrocarbons (branched, aromatics and cycloalkanes) and this can change depending on the season, e.g. in the winter you would need a petrol which was more volatile. Companies change their blend 3 or 4 times a year.

Alternative Fuels

Biogas	Methane is produced by anaerobic respiration of biological materials.
Ethanol	Produced by fermentation e.g. sugar cane. It has an octane rating of 111. In Brazil about 20% of their 'petrol' is ethanol.
Methanol	A liquid, made from steam and methane. Octane rating of 114, also 'clean' burning. Toxic and corrosive
Hydrogen economy	The dream fuel, but needs electricity to make it. It burns to produce water.
Fuel Cells	Twice as efficient as the internal combustion engine. Requires a source of hydrogen and oxygen.

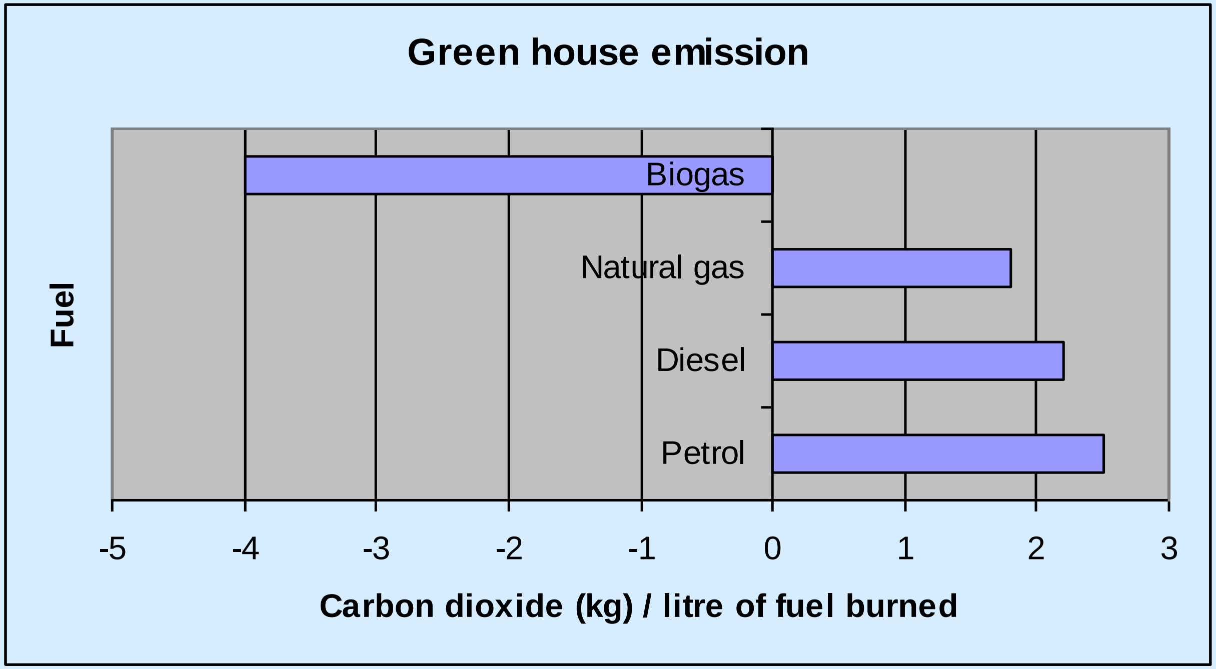
Did you know?

CFC's were replaced by HFC's which do not destroy the ozone layer. However, they are greenhouse gases which are 1200 times more powerful than CO_2.

A fridge contains 0.67kg of HFC's, equivalent to 800 kg of CO_2 . For this reason, some fridges now use HC's, such as butane and propane. These are only 3 to 4 times more powerful than CO_2 as a green house gas.

Did you know?

Methane is 23x more powerful as a greenhouse gas as CO_2. Sewage methane can replace the use of natural gas for the generation of electrical power.



So why does burning biogas give a negative value?