National 4/5 Chemistry
Unit 2: Nature's Chemistry
Revision

Topic 1 Fuels

A fuel is a substance that can be burned to release energy.

The burning of a fuel is called **combustion**. Combustion is the reaction of a substance with oxygen, giving out energy.

The burning of a fuel releases energy to the surroundings, so the burning of a fuel is an example of an exothermic reaction.

When a fuel burns oxygen is used up.

- The chemical test for oxygen is that it relights a glowing splint.

A fossil fuel is a fuel which is formed over millions of years from the remains of living things.

Fossil Fuels		
Coal	Oil	Gas

How Coal is Made	**How Oil & Gas are Made**
Tree and plant materials die, fall to the bottom of a swamp and get covered in mud.	Sea organisms die and fall to the bottom of the sea and get covered in sand.
Dead materials get compressed by heavier and heavier layers of rock.	
Over millions of years, dead materials turn into coal, oil or gas (depending on the starting material)	
Coal is then mined out of the ground.	Fuel companies drill for oil and gas.

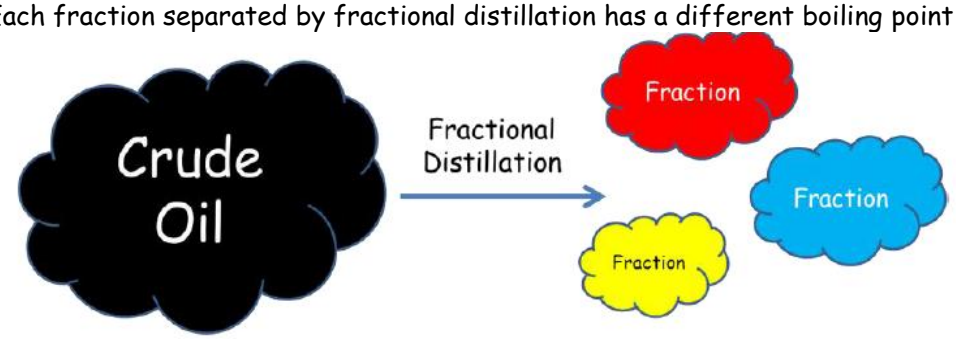
Pollution problems which are associated with the burning of coal, oil and gas are:

Pollutant Gas	Reason for Formation	Environmental Issue
sulfur dioxide	Formed from the burning of sulfur impurities in coal.	Dissolves in atmospheric moisture to form acid rain.
carbon dioxide	Formed from burning any carbon-based fossil fuel.	Contributes to Global Warming (The Greenhouse Effect).
carbon monoxide	Formed by incomplete combustion (where the supply of oxygen is limited).	Carbon monoxide is a poisonous gas.
nitrogen dioxide	Produced by the spark in a car engine reacting with nitrogen and oxygen in the air.	Dissolves in atmospheric moisture to form acid rain.

Crude oil is a mixture of compounds called **hydrocarbons**.

Fractional distillation is used to separate crude oil into **fractions** according to their boiling point.

- A fraction is group of compounds with a similar boiling point.
- Each fraction separated by fractional distillation has a different boiling point range.



Fractions obtained from the fractional distillation of crude oil have a variety of uses.

Petroleum Gas	Naphtha	Kerosene	Light Gas Oil	Heavy Gas Oil	Residue
bottled gases, Calor gas	petrol, making plastics	aircraft fuel, paraffin	diesel	ship fuel, lubrication oil	bitumen, tar

Viscosity is the measure of the thickness of a liquid.

- The more viscous a substance is, the thicker it is and the less easily it flows.

Flammability means how easily a substance catches fire.

- The bigger a molecule is, the less flammable it is.

CH_4 Fractions with Smaller Molecules	As the molecular size increases: →	$C_{20}H_{42}$ Fractions with larger Molecules
	Evaporation becomes more difficult	
	The flammability decreases	
	The viscosity (thickness) increases	
	The boiling point increases	

Complete combustion of a fuel is when it is burned in a plentiful supply of oxygen.

Incomplete combustion of a fuel is when it is burned in a limited supply of oxygen.

- In carbon based fuels this can lead to the formation of poisonous carbon monoxide.

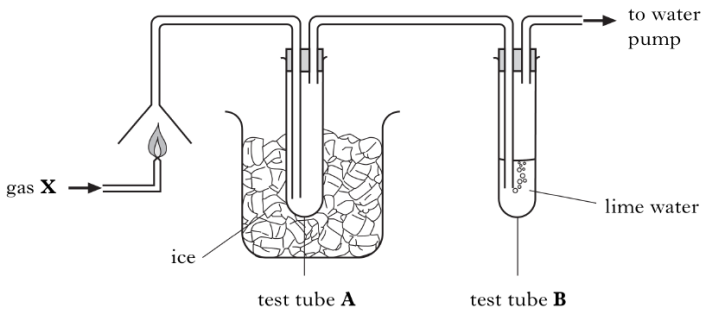
A **hydrocarbon** is a compound which contains only carbon and hydrogen.

Complete combustion of a hydrocarbon results in the formation of carbon dioxide and water.

- Hydrogen burns in oxygen to form hydrogen oxide (water)
- Carbon burns in oxygen to form carbon dioxide.

Hydrocarbon + Oxygen → Carbon dioxide + Water

The following apparatus could be used to examine the products of combustion of a hydrocarbon.



Air pollution from the burning of hydrocarbons can be reduced by adding catalytic converters to car exhausts which contain platinum catalysts. Catalytic converters convert harmful gases into harmless gases.

The energy produced by a fuel can be calculated using the following formula:

$$E_h = cm\Delta T$$

where:

- E_h = the energy given out in the reaction, measured in kilojoules (kJ)
- c = the specific heat capacity of water, 4.18 kJ kg^{-1} $°C^{-1}$ (in data booklet)
- m = mass of water being heated, which must be in kg (e.g. 75 cm^3 water = 75/1000 kg)
- ΔT = the change in temperature of the water (°C)

Key area: hydrocarbons

A **homologous series** is a group of compounds with:

- similar chemical properties
- the same general formula
- a gradual change in physical properties such as melting and boiling point.

Examples of homologous series include groups of compounds called the **alkanes**, **cycloalkanes** and **alkenes**.

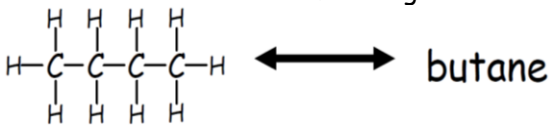
The Alkanes

The alkanes are the simplest homologous series of hydrocarbons.

- The names of the first eight alkanes are:

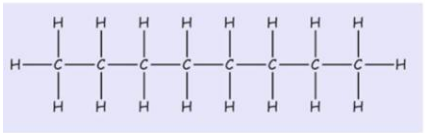
No. C's	1	2	3	4	5	6	7	8
Name	methane	ethane	propane	butane	pentane	hexane	heptane	octane

- You need to be able to name **and** draw the first eight alkanes.

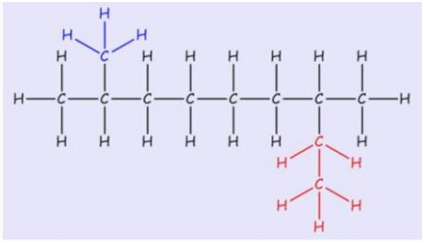


- The names of the alkanes always end in …**ANE**.
- The alkanes contain C-C single bonds.
- The general formula for the alkanes is C_nH_{2n+2}.

Alkanes can be **straight chained** like the above, or **branched**.



Straight chain

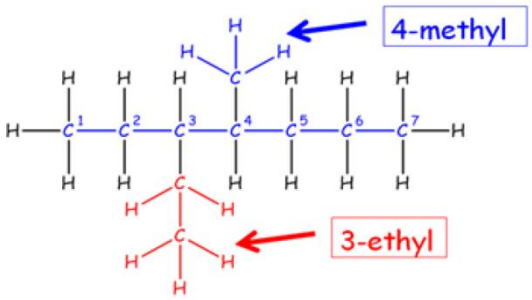


Branched

Branched alkanes can be named systematically according to rules set down by the International Union of Pure and Applied Chemistry (IUPAC).

- Find the longest continuous chain of carbons
- Identify any branches off the longest chain, e.g. methyl or ethyl
- Put the name together with the branches first and the name of the long chain last. *The longest chain should be numbered to give branches the lowest possible number.*

e.g.



Here the longest chain is 6 carbons.

There is an ethyl branch on carbon 3 and a methyl branch on carbon 4.

So this is:

3-ethyl-4-methylhexane

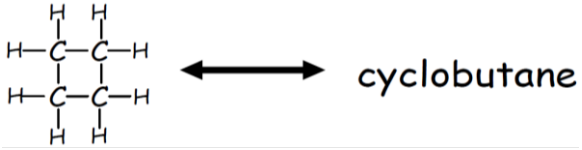
The Cycloalkanes

The cycloalkanes are a homologous series of hydrocarbons with cyclic shapes.

- The names of the first five cycloalkanes are:

No. C's	1	2	3	4	5	6	7
Name	Doesn't exist	Doesn't exist	cyclopropane	cyclobutane	cyclopentane	cyclohexane	cycloheptane

- You need to be able to draw and name the cycloalkanes.



- The names of the cycloalkanes start with **CYCLO**… and end with ….**ANE**.
- The cycloalkanes contain C-C single bonds.
- The general formula for the cycloalkanes is C_nH_{2n}.

The Alkenes

The alkenes are another homologous series of hydrocarbons.

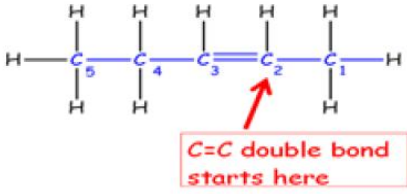
- The names of the first seven alkenes are:

No. C's	1	2	3	4	5	6	7	8
Name	Doesn't exist	ethene	propene	butene*	pentene*	hexene*	heptene*	octene*

*Names should have numbers to show the position of C=C

- You need to be able to name and draw the alkenes.

- The names of the alkenes always end in …**ENE**.
- The name of alkenes sometimes has a number in it, e.g. pent-1-ene. The number tells us where the C=C is.

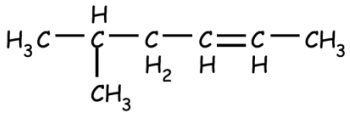


This would be:

pent-2-ene

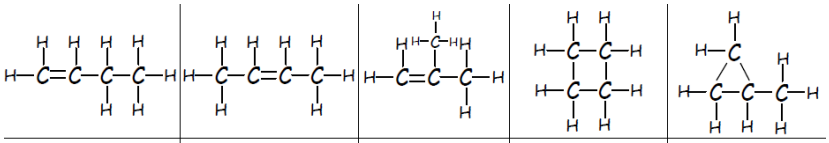
- Alkenes contain at least one C=C double bond. This is called the functional group, which means it is the part of the molecule that reacts.
- The general formula for the alkenes is C_nH_{2n}.

Alkenes can also be straight chain or branched. Branched alkenes are named in the same way we named branched alkanes. The position of the C=C double bond is numbered first and then the branches are numbered in this case however. For example:



5-methylhex-2-ene

An **isomer** is when you have compounds that have the same molecular formula but a different structural formula.



C_4H_8	C_4H_8	C_4H_8	C_4H_8	C_4H_8

Saturated hydrocarbons contain only C-C single bonds.

- The alkanes are saturated hydrocarbons.
- The cycloalkanes are saturated hydrocarbons.

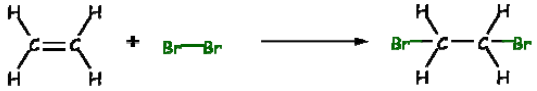
Unsaturated hydrocarbons contain C=C double bonds.

- The alkenes are unsaturated hydrocarbons.

The bromine solution test can be used to distinguish between saturated and unsaturated hydrocarbons.

- Unsaturated hydrocarbons immediately decolourise bromine solution.
- Saturated hydrocarbons do not immediately decolourise bromine solution.

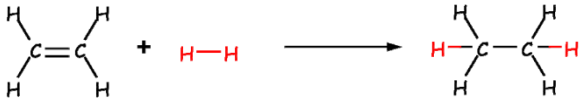
When an unsaturated hydrocarbon, such as an alkene, reacts with bromine solution a reaction called **ADDITION** has occurred.



Ethene + Bromine → Dibromoethane

C_2H_4 + Br_2 → $C_2H_4Br_2$

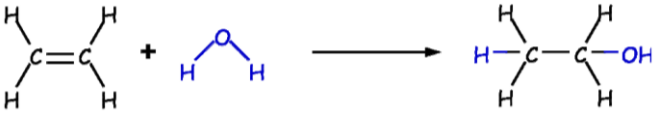
The addition of hydrogen to an alkene is called **HYDROGENATION**. Adding hydrogen to an alkene forms an alkane.



Ethene + Hydrogen → Ethane

C_2H_4 + H_2 → C_2H_6

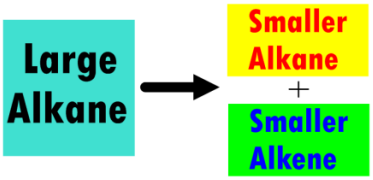
The addition of water to an alkene is called **HYDRATION**.



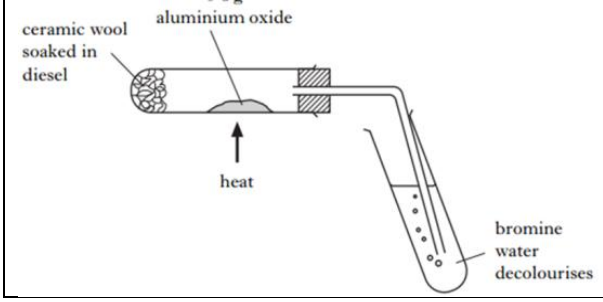
Ethene + Water → Ethanol

C_2H_4 + H_2O → C_2H_5OH

Cracking is when you take a large alkane and break it down into a smaller alkane and a smaller alkene.



The following apparatus can be used to carry out cracking in a laboratory.



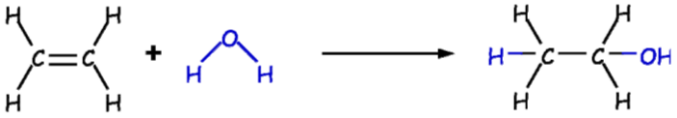
The aluminium oxide is a catalyst in this reaction.

When carrying out the experiment, the delivery tube must be removed from the bromine before you stop heating to prevent **suckback**.

Key area: consumer products

Alcohols are a homologous series containing the **hydroxyl functional group**, **-OH**.

Alcohols can be made by the hydration of alkenes.



Ethene + Water → Ethanol

C_2H_4 + H_2O → C_2H_5OH

Alcohol can also be made by the fermentation of glucose which is catalysed by the enzymes found in yeast.

glucose —(Yeast)→ ethanol (alcohol) + carbon dioxide

Alcohols

- Are a homologous series of compounds containing the hydroxyl functional group, -OH.
- The names of the first eight members are:

No. C's	1	2	3	4	5	6	7	8
Name	methanol	ethanol	propanol*	butanol*	pentanol*	hexanol*	heptanol*	octanol*

*names will also have a number in them telling you the position of the -OH group.

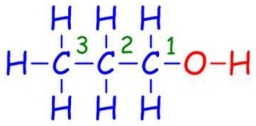
- You need to be able to name and draw the above alcohols.

- The name of an alcohol ends in …**OL**.
- The general formula for the alcohols is $C_nH_{2n+1}OH$

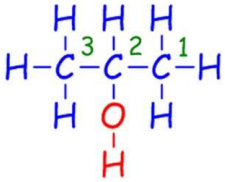
In alcohols with more than 3 carbons in their chain, the –OH group can be in different positions on the chain. To show where the –OH group is, we can place a number in the name of the alcohol.

For example:

Propan-1-ol



Propan-2-ol



Propan-1-ol and propan-2-ol are **isomers**, as they have the same molecular formula but a different structural formula.

Small alcohols such as methanol, ethanol and propanol are soluble in water. Longer carbon chained alcohols are not soluble in water.

Alcohols are useful as solvents. They are found in a variety of skincare products as some alcohols are able to dissolve the oils present in skin.

Alcohols are highly flammable, which means they make good fuels.

Alcohols make good fuels as they burn with a much cleaner flame than hydrocarbon fuels.

Ethanol, which can be made by fermentation, is becoming more widely used as a fuel for vehicles.

Alcohols can be converted into another type of chemical, called a **carboxylic acid**.

Carboxylic acids are a homologous series of compounds which contain the **carboxyl functional group**.

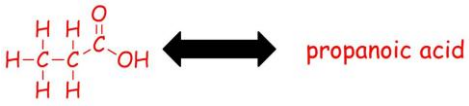
The carboxyl functional group 

Carboxylic Acids

- Are a homologous series of compounds contain the carboxyl functional group (COOH)
- The names of the first five members are:

No. C's	1	2	3	4	5
Name	methanoic acid	ethanoic acid	propanoic acid	butanoic acid	pentanoic acid

- You need to be able to name and draw carboxylic acids



- Their names all end in ……**ANOIC ACID**.
- They have the general formula $C_nH_{2n+1}COOH$.

Ethanoic acid is more commonly known as vinegar.

Carboxylic acids can have a variety of uses:

- as preservatives
- as cleaning products as they are weak acids
- in the food industry.

Carboxylic acids tend to have an unpleasant smell, e.g. butanoic acid. This acid is formed when butter becomes rancid.

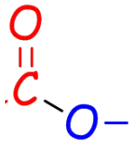
Carboxylic acids can react with alcohols to form a compound called an **ester**.

Alcohol + Carboxylic Acid $\rightleftharpoons$ Ester + Water

When an ester is made, water is also formed. This type of reaction is called a condensation reaction.

Esters are compounds which contain an ester functional group. An ester functional group has the following structure.

The ester functional group



You need to be able to identify this functional group if you are given the structural formula of a substance.

Esters have **sweet smells**. They are found in many everyday products.

Esters have a variety of uses:

- as fragrance compounds
- as flavourings in foods
- as cleaning agents
- as solvents, e.g. nail varnish remover.

Esters are found in fats and oils.