National 5
Unit Two : Nature's Chemistry

Fuels

A **fuel** is a chemical which burns, giving off energy.
Combustion is a reaction of a substance with **oxygen** giving off energy.
The test for **oxygen** is it relights a glowing splint.
The main components of air are oxygen and nitrogen in proportion of 1:4.
An **exothermic** reaction is one in which energy has been released (given out). This feels hot to the touch.
Finite energy resources will run out. This means there will be a fuel crisis in relation to the amount of coal, oil and natural gas in the earth.

Fossil fuels (coal, crude oil, natural gas) were formed over about 300 million years. Coal was formed from trees which fell in swamps, oil and gas from microscopic sea creatures and plants which fell to the bottom of the sea. Layers of sediment formed on top and under pressure the decaying material turned into the fossil fuels.
Sulphur is an impurity in fossil fuels so when they are burned **sulphur dioxide** is given off. This dissolves in rain water to make acid rain. **Carbon dioxide** is also acidic and slightly soluble in water.
Nitrogen dioxide is formed by an electrical spark in a car engine or lightning storms in air. This also contributes to acid rain.

Crude oil is a mixture of compounds, mainly **hydrocarbons**. A hydrocarbon is a compound which contains hydrogen and carbon **only**. Natural gas is also mainly hydrocarbons.
Fractional distillation is the process used to separate crude oil into fractions.
A **fraction** is a group of compounds with boiling points within a given range.
Fractions can be separated by distillation because they have different **boiling points** so evaporate at different times when crude oil is heated. They then cool down to be collected as liquids.
The fractions from crude oil can be used for camping gas, petrol, diesel, candle wax, and tar (bitumen), depending on their size and properties.
Flammability is how easily a substance catches fire. **Viscosity** is how thick a liquid is. **Volatility** is how easily a substance evaporates.

As the **average size** of the molecules in a fraction **increases**:

Volatility decreases

Flammability decreases

Viscosity increases

These changes are due to increased **Van der Waals'** forces between the molecules.

The test for carbon dioxide is it turns lime water milky. The test for water is it turns cobalt chloride paper from blue to pink and boils at 100°C and freezes at 0°C.

Hydrocarbons burn **completely** to produce only **carbon dioxide** and **water**.

If carbon dioxide and water are produced when a substance burns it means carbon and hydrogen were present. You can't be sure the oxygen came from the substance as oxygen is in air.

Carbon (soot), and carbon monoxide, a poisonous gas, are produced when hydrocarbons burn in a supply of oxygen which is insufficient for complete combustion. This is known as **incomplete combustion**.

Removing sulphur compounds reduces air pollution.

Lead compounds which are added to petrol cause pollution and cause brain damage.

Air pollution from the burning of hydrocarbons can be reduced by special exhaust systems (**catalytic converters**) or by altering the **fuel to air ratio**:

Transition metal catalysts (Platinum and Rhodium) can convert the pollutant gases to harmless gases.

Reducing the fuel to air ratio improves the efficiency of combustion thus decreasing pollution because combustion is more complete.

Pollution from Cars

Carbon dioxide (greenhouse effect)

Sulphur dioxide and nitrogen dioxide (acid rain)

Carbon monoxide and soot (from incomplete combustion)

Lead compounds (from leaded petrol)

Alternative Fuels

Ethanol - from fermentation of sugar cane.

Hydrogen (fuel cell) – from electrolysis of water.

Biogas – from decaying plant material giving 60% methane.

Naming Carbon Compounds

1. Find the longest carbon chain with the functional group in it.
2. Base name on this using same prefixes as alkanes.
3. Number chain to give functional group lowest number possible.
4. Name any side groups. Alkane-based groups become 'alkyl', halogens such as chlorine become 'chloro'.
5. Give position of side groups with number in front.
6. Position of functional group in alkenes, alkynes, alkanols, given by number within the name, eg. but-1-ene, butan-1-ol.
7. Number not needed for position of functional group in alkanoic acids. Always carbon number 1.
8. Side groups listed in front in alphabetical order (ignoring any prefix such as 'di' and 'tri').
9. Ring compounds named to give lowest numbers possible.

(Full) Structural Formula – shows ALL bonds.
Shortened Structural Formula – only shows bonds to side groups. H atoms listed next to each C atom, eg. $CH_3CH_2CH_3$

Alkanes (C_nH_{2n+2})

Reactions:
Substitution with bromine (needs uv light)
Cracking (over aluminium oxide) ⟶ **alkene**

Alkenes (C_nH_{2n}) carbon-carbon double bond C=C

Formed by:
1. Cracking of an **alkane** (Al_2O_3 catalyst)
2. Dehydration of an **alkanol** (Al_2O_3 catalyst)

Reactions:
Addition:
1. H_2 (hydrogenation) ⟶ alkane (Pt catalyst)
2. Bromine water ($Br_2(aq)$) ⟶ dibromoalkane (**The Bromine Test for unsaturation**)
3. Water (hydration) ⟶ alkanol

Cycloalkanes (C_nH_{2n})

Isomers with **alkenes** but similar reactions to **alkanes**, ie. Cannot undergo addition so don't decolourise bromine water.

Alcohols $C_nH_{2n+1}OH$ (contain a hydroxyl group, –OH)

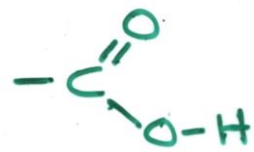
Ethanol formed by:
1. Fermentation
2. Hydration of an alkene (with catalyst)

Reactions:
1. **Dehydration** ⟶ alkene (Al_2O_3 catalyst)
2. **Combustion** ⟶ carbon dioxide + water
3. **Esterification** with carboxylic acid ⟶ **ester**

Alcohols have higher than expected melting and boiling points due to the polar O-H bond. This creates strong hydrogen bonds between molecules on top of the Van der Waal's forces.

Carboxylic acids (alkanoic acids) $C_nH_{2n+1}COOH$

Contain a carboxyl group



Weak acids (not completely ionised).

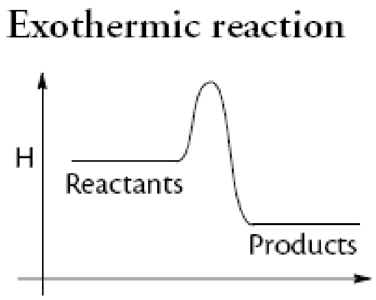
Reactions of carboxylic acids:
1. **Neutralisation** – with an alkali, metal oxide, metal carbonate. Also react with MAZINTL metals in a **displacement** reaction.
2. **Esterification** with an alkanol ⟶ **ester**

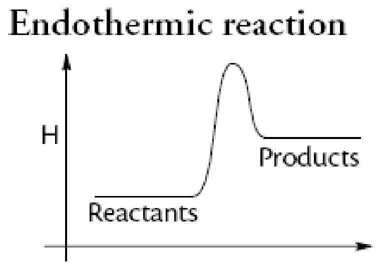
Uses:
Vinegar (ethanoic acid), limescale remover (methanoic acid), making esters.

Esters

Sweet smelling and tasting. Used in perfumes, flavourings solvents, paints.
Formed by:
Condensation reaction between an **alcohol** and **carboxylic acid**.

Energy from Fuels





$$E = c\,m\,\Delta T$$

E = energy change (in kJ)
c = the specific heat capacity of water, 4.18 kJ kg^{-1} $°C^{-1}$
m = the mass of water (in kg)
ΔT = temperature change of the water (in °C)

Carbohydrates (National 4)

Contain carbon, hydrogen and oxygen but the H:O ratio is 2:1 as in water, eg. Glucose is $C_6H_{12}O_6$, Maltose is $C_{12}H_{22}O_{11}$.
Source of energy through **respiration**.
Glucose undergoes condensation polymerisation ⟶ starch
Starch undergoes hydrolysis by **enzymes** (digestion) or by **heating with acid**
⟶ maltose ⟶ glucose
Test for starch: iodine turns from **brown** to **blue/black.**
Test for Reducing sugars: Benedict's solution turns from **blue** to **orange/brick red**.

All common carbohydrates except starch and sucrose react with Benedict's solution.

Sucrose is the only common carbohydrate to give **negative** results with **both tests**.