National 4
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

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.

<u>Pollution from Cars</u>
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.

Hydrocarbons

(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)

Reactions:
Addition:

+ Bromine water ($Br_2(aq)$) ⟶ dibromoalkane
(**This is the Bromine Test for double bonds**)

Cycloalkanes (C_nH_{2n})

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

Carbohydrates

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 **s**tarch and **s**ucrose react with Benedict's solution.

Sucrose is the only common carbohydrate to give **negative** results with **both tests**.
Glucose is made by a process called Photosynthesis in plants. Plants convert glucose into starch for storage. The green pigment called Chlorophyll is needed.
Photosynthesis equation
Carbon dioxide + Water → Glucose + Oxygen
(into leaf from air) (through roots)

Digestion breaks starch into glucose in the body so that the small molecule, glucose can go to cells for respiration. Amylase is an enzyme in saliva to help break down starch.
Respiration Equation (in all living cells)
Glucose + Oxygen → Carbon dioxide + water + ENERGY.
(food) (air) (breathed out)

Enzymes are biological catalysts. They spped up reactions in living things. They work at OPTIMUM or best conditions. Human Enzymes optimum temperature is 37^0C. Optimum pH for amylase is pH 7 whereas protease in stomach has optimum pH about 2.
Enzymes are **denatured** (damaged) if they are moved too far from optimum conditions.

Alcohol and Drugs

A drug is a substance which alters the way the body works.
Drugs can damage health because of the way they can affect the body and lifestyle.

Alcohol is a drug which, if taken in excess, can have many harmful effects on the body, particularly the liver and brain.

A bottle of Alcopop or a pint of beer contain approximately **2 units** of alcohol; a pub measure of spirits and a glass of wine contain approximately **1 unit** of alcohol.
Alcohol is broken down by the body at about 1 unit per hour.
Alcoholic drinks can be made by **fermentation** of starch and sugars present in fruit and vegetables.
The type of alcoholic drink varies with the plant source of carbohydrate.
During **fermentation** glucose is broken down to form alcohol; carbon dioxide is also produced.
The fermentation process is catalysed by the enzymes in yeast.
The alcohol produced by fermentation is called **ethanol**.
Distillation is a method of increasing the alcohol concentration of fermentation products.
Water and alcohols can be partially separated by distillation because they have different **boiling points**.

Other Drugs

Some drugs including medicines, alcohol, nicotine and caffeine are legal; others including cannabis. **LSD** and **ecstasy** are illegal.
Being unable to manage without a drug is called addiction.
Methanol, another alcohol, is very toxic causing blindness and death.
Methylated spirits (meths) contains methanol and has both a colour and a bad tasting substance added to it to prevent people drinking it.
Chemical reactions are going on all the time to keep the body working properly.

Medicines contain drugs which help the body when it is not working correctly.
Some drugs, including **antibiotics**, can fight micro-organisms which interfere with the chemical reactions.
Medicines are usually made up of many chemicals and only the **active ingredient** works on the body.

Many medicines are chemicals which came originally from **plants** or can be made from plant chemicals.

Drug	Plant it comes from	Used for
Aspirin	Willow bark	Pain relief
Morphine	Opium poppy	Strong painkiller
Quinine	Cinchona	Malaria
Digoxin	Foxglove	Heart disease

Plants also give us chemicals for:

- Biofuels, such as bioethanol
- Dyes (indigo for denim comes from the plant, *indigofera tinctoria*)
- Fibres (cotton comes from a cotton plant)
- Medicines and drugs