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Chemistry Topic 8
Rates and equilibrium

Section 1: Rate of reaction Key terms

Rate of reaction	Tells you **how fast** reactants turn into products
Collision theory	**Reactions can only take place** when **particles collide with enough energy**.
Activation energy	The minimum amount of **energy particles** need in order **to react**.
Catalyst	A chemical (or **enzyme**) that **increases the rate of reaction without being used up itself**. They **provide an alternative pathway** for the reaction with a **lower activation energy**.
Concentration	The **number of particles** in a certain **volume.**
Surface area	The surface area of a solid is a measure of the **total area** that the **surface of the solid occupies**.
Pressure	The pressure of a gas is the **force** that the **gas exerts** on the **walls of the container**.

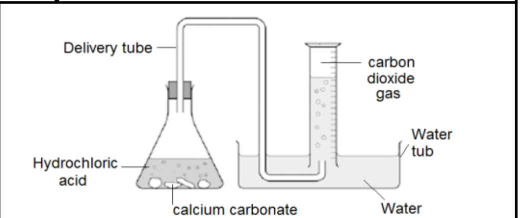
Section 2: How can you find out the rate of reaction

There are two ways you can work out the rate of a chemical reaction. You can find out how quickly:

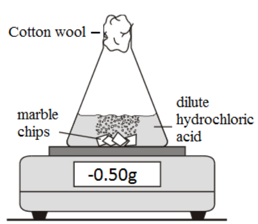
- The reactants are used up
- The products are made

There are **three techniques** that can be used:

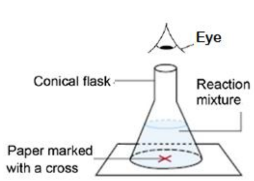
1. Measuring the increasing volume of a gas given off.



2. Measuring the decreasing mass of a reactant mixture.



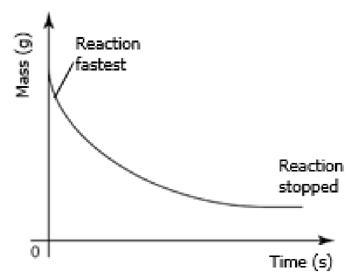
3. Disappearing cross method: measuring the decreasing light passing through a solution.



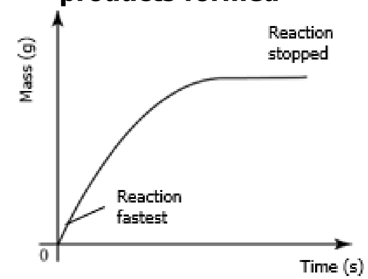
Section 3: Calculating rate of reaction

$$\text{Mean rate of reaction} = \frac{\text{quantity of reactant used}}{\text{time}}$$ *or* $$\text{Mean rate of reaction} = \frac{\text{quantity of product formed}}{\text{time}}$$

Typical graph when measuring **reactants used**



Typical graph when measuring **products formed**



Section 4: Factors Affecting Rate of reaction

Factor	Effect on Rate	Explanation
Concentration of reactants	Increasing the concentration **increases** the rate of reaction.	**Increases the frequency of a collision** as particles are **closer together**.
Pressure **of gases**	Increasing the pressure **increases** the rate of reaction.	**Increases the frequency of a collision** as particles are **closer together**.
Surface area of solid reactants	Increasing the surface area **increases** the rate of reaction.	**Exposes more of the solid** so that there is a **greater frequency of collisions** occurring.
Temperature	Increasing the temperature **increases** the rate of reaction.	Particles **collide more frequently** and with **more energy**.
Catalyst	Catalysts **increase** the rate of reaction.	**Lowers** the **activation energy** by providing an **alternate pathway**.

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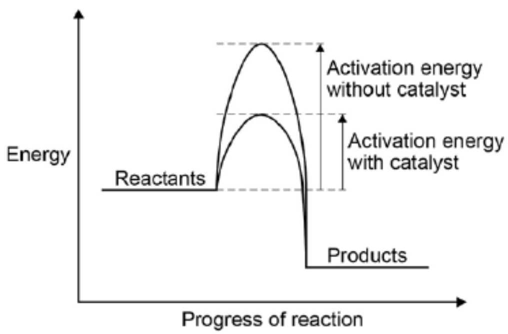
Section 4 (cont): How Catalysts work

The reaction profile diagram of an uncatalysed and a catalysed exothermic reaction is shown below. The catalyst lowers the activation energy of the reaction.



Section 5: Reversible Reactions key terrms

Reversible reaction	A reaction in which the **products can also form the reactants**. Its symbol is ⇌ Shown as: A + B ⇌ C + D
Exothermic	A reaction that **transfers energy to** the **surroundings**
Endothermic	A reaction that **takes in energy from** the **surroundings**
Equilibrium (HT)	Equilibrium is reached when the **forward and backwards reactions** occur at **exactly the same rate**. The **amounts of reactants and products present remain constant**. Requires a **sealed container**.
Le Chatelier's Principle (HT)	When a **change in conditions** is introduced to a system at equilibrium, the **position of equilibrium shifts** so as **to cancel out the change.**

Section 6: Altering conditions (HT)

	If the forward reaction is exothermic	If the forward reaction is endothermic
Changing temperature (HT)	An **increase in temperature** shifts the equilibrium in the **backwards (endothermic) direction**. Hence the amount of **products decreases.**	An **increase in temperature** shifts the equilibrium in the **forwards (endothermic) direction**. Hence the amount of **products increases**.
	A **decrease in temperature** shifts the equilibrium in the **forwards (exothermic) direction**. Hence the amount of **products increases**.	A **decrease in temperature** shifts the equilibrium in the **backwards (exothermic) direction**. Hence the amount of **products decreases**.
Changing concentration (HT)	• If we increase the concentration of one of the reactants, Le Chatelier's principle says that the **equilibrium will shift in the direction** that tends to **reduce the concentration** of this reactant. A + B ⇌ C + D • Increasing the concentration of reactant A, the only way the system can reduce the concentration of A, is by some of A reacting with B. Hence the equilibrium moves in the forwards direction and more C & D are made. • If the **concentration of a reactant is increased**, the equilibrium shifts in **the forwards direction** to decrease the amount of reactant, **hence more products** will be formed. • If the concentration of a product is decreased, more products will be formed.	
Changing pressure (HT)	For reactions of **gases**: • an **increase in pressure** causes the reaction to favour the **side with the smaller number of molecules** (as shown by the balanced symbol equation for that reaction). • A **decrease in pressure** causes the reaction to favour the **side with the larger number of molecules** (as shown by the balanced symbol equation for that reaction). e.g. $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$ • **Decreasing the pressure** in this reaction shifts the equilibrium to the side with the **most gas molecules.** Hence the equilibrium shifts in the **forwards direction**.	

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Chemistry Topic 9
Crude oil and fuels

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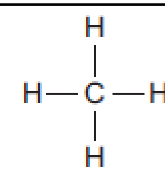
Section 1: Key terms

Crude oil	A **mixture** of **hydrocarbons** formed over **millions of years** from dead **plankton** subjected to **high pressure & temperature**.
Hydrocarbon	A molecule containing **hydrogen** and **carbon** atoms **only**.
Alkane	A **hydrocarbon** containing only **single bonds**. Follows the formula $\mathbf{C_nH_{2n+2}}$.
Fractional distillation	The method of **separating hydrocarbons** based on their **boiling point**.
Fraction	A fraction contains **similar length hydrocarbons** with a **small range of boiling points**.
Intermolecular force	**Weak forces of attraction** that exist between **molecules**.
Boiling point	The temperature at which a **liquid** turns into a **gas**.
Viscosity	The ability of a substance to **flow**.
Volatility	The tendency to turn into a gas
Flammability	How easily a substance **burns** or **ignites**.
Combustion	A **reaction** between a **fuel** and **oxygen** that produces **heat**.
Complete combustion	Combustion in **plenty of oxygen**. Complete combustion of a hydrocarbon will produce **carbon dioxide** and **water**.
Incomplete combustion	Combustion in **inadequate oxygen**. Incomplete combustion of a hydrocarbon produces **water** and **carbon monoxide or carbon particulates**.
Alkene	A **hydrocarbon** containing at least one **double bond**. They follow the formula $\mathbf{C_nH_{2n}}$. Used to make **polymers**.
Bromine water	A chemical that is **brown/orange** in colour. If added to an **alkene** it reacts and changes to **colourless**. Alkanes do not react hence do not produce a change in colour.
Cracking	The process by which less-useful **long-chain hydrocarbons** are **split** to produce an **alkane** and an **alkene**.
Catalyst	A chemical that **speeds up the rate of reaction** without being used up itself.

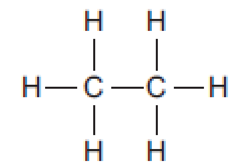
Section 2: Alkanes

Most of the hydrocarbons in crude oil are alkanes. The general formula of an alkane is $\mathbf{C_nH_{2n+2}}$ The alkanes are **saturated hydrocarbons** with all the **carbon-carbon bonds** being **single covalent bonds**.

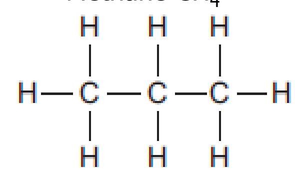
Prefix	Number of carbon atoms
Meth-	1
Eth-	2
Prop-	3
But-	4



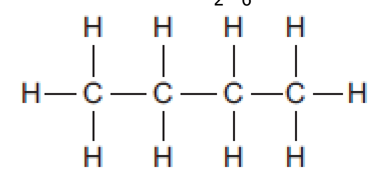
Methane CH_4



Ethane C_2H_6



Propane C_3H_8



Butane C_4H_{10}

Section 3: The properties of the alkanes

Boiling points	Alkanes have **low boiling points** (the first four alkanes are gases at room temp.) Between these simple molecules are **weak intermolecular forces** of attraction which **don't require much energy** to overcome.
Viscosity	Longer chain alkanes are **more viscous** because they have **stronger intermolecular forces** and stick together more making them thicker liquids.
Volatility	**Shorter chain** alkanes are **more volatile** than larger chain alkanes because they **have weaker forces of attraction** between their molecules than longer chain
Flammability	Flammability **decreases** with **chain length** because more oxygen is needed for combustion (burning) so they don't burn as well.

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Chemistry Topic 9
Crude oil and fuels

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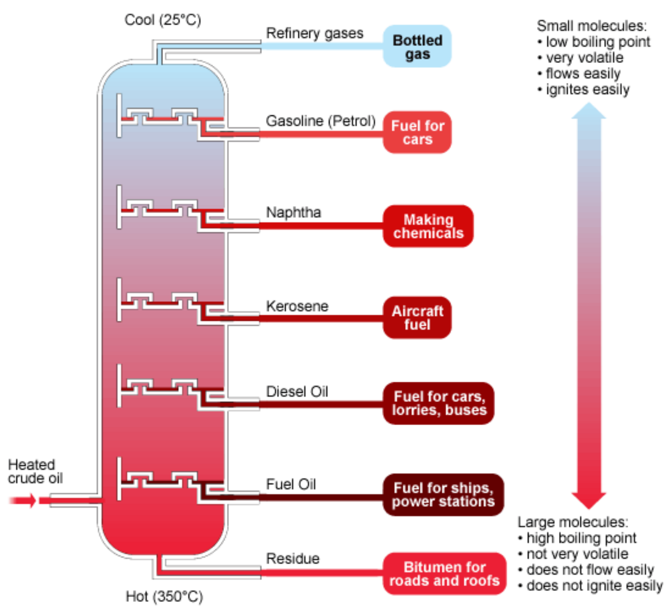
Section 4: Fractional distillation of oil

Crude oil is separated into hydrocarbons with similar boiling points. Each hydrocarbon fraction contains molecules with similar numbers of carbons.

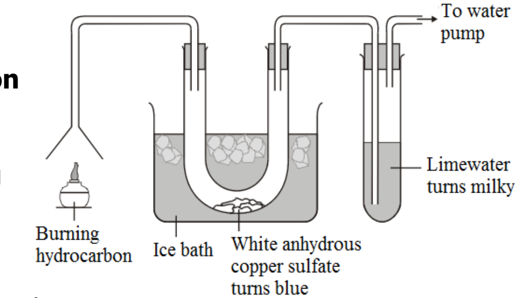
- The crude oil is **heated** to about 370ºC and fed into bottom of a fractionating column.
- The fractionating column is hottest at the bottom & coolest at the top.
- Most fractions **evaporate** and become **vapours**. The residue (heavier long chain molecules) doesn't boil & flows to the bottom of the column.
- Hot vapours (shorter chain molecules) **rise** up the column & **cool down**.
- When the vapours **cool** to their **boiling point** they **condense** and flow out of the column.
- Those with **lower boiling points rise further** before cooling down.
- Refinery gases do not cool down to their boiling point so **remain as gases**.
- Large chain fractions are cracked producing smaller more useful fuels.



Section 5: Burning hydrocarbon fuels

Obtained from the **fractional distillation and cracking** of crude oil.
The combustion of hydrocarbon **fuels releases energy**.
During combustion, the carbon and hydrogen in the fuels are **oxidised.**
Complete combustion – alkanes will burn in oxygen to produce carbon dioxide and water. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
Incomplete combustion – when there is **not enough oxygen**, **carbon monoxide and carbon particulates** also form.

You can **test the products** given off when a **hydrocarbon burns** using the apparatus opposite. As well as using anhydrous copper sulfate, you can also use **blue cobalt chloride paper** which turns **pink** when water is present.

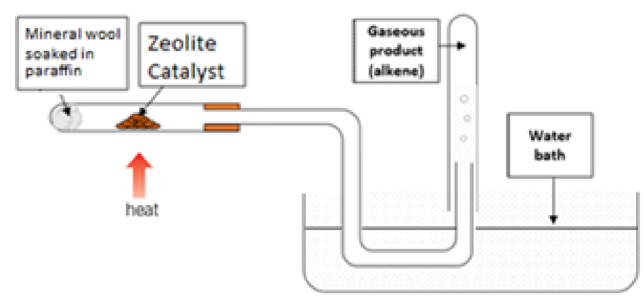


Section 6: Cracking

Cracking – breaks long chain hydrocarbons into more useful shorter chain hydrocarbons. Cracking can be done by either catalytic cracking or steam cracking. Cracking can also be described as a **thermal decomposition.**

Method	Process	**Temperature**
Catalytic Cracking	passed over a hot zeolite catalyst	**500ºC.**
Steam Cracking	mixed with steam and heated to a very high temperature.	**850ºC.**

e.g. Cracking of Decane. $C_{10}H_{22} \rightarrow C_5H_{12} + C_3H_6 + C_2H_4$



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Chemistry Topic 12
Chemical analysis

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Section 1: Key terms

Pure	A pure substance is a single **element** or **compound**, **not mixed** with anything else.
Formulation	**Useful mixtures** that have a precise purpose. The quantity of each component in a formulation has been measured carefully. Formulations include **fuels**, **cleaning agents**, **paints**, **medicines**, **alloys**, **fertilisers** & **foods**.
Melting point	The **temperature** at which a substance turns from a solid to a liquid.
Boiling point	The **temperature** at which a substance turns from a liquid to a gas.
Chromatography	An analytical method used to **separate substances** in a **mixture**.
R_f value	**Retention factor**. A ratio, calculated by dividing the distance moved by a spot up the paper by the distance the solvent front travels.
Solvent	The chemical that **dissolves the sample** in chromatography.
Solvent front	The **maximum distance** the **solvent moves** up the paper.
Stationary phase	The phase where the molecules can't move. The **medium** (e.g. paper) through which the **mobile phase passes** in **chromatography**.
Mobile phase	The phase (in chromatography), where **molecules can move**. The **solvent** (e.g. water) that carries the sample (e.g. ink).
Energy levels	Electrons orbit the nucleus in specific energy levels (or **shells**).

Section 2: Pure substances and mixtures

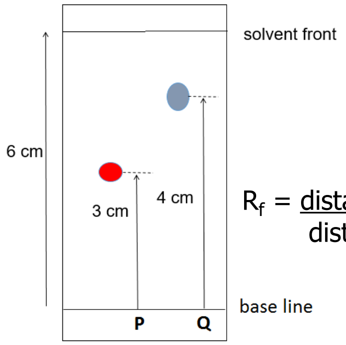
You can use melting points and boiling points to identify pure substances. The **test for pure water** is that it **melts at exactly 0°C** and **boils at exactly 100°C**. These fixed points can be looked up in data books.
A **mixture does not** have a **sharp melting point or boiling point**, it changes state over a **range of temperatures**.
Impurities will **lower the melting point** of a substance and **increase its boiling point**. The purer the compound is, the narrower the melting point range. Crude aspirin made in the lab has a melting point between 128-132°C, whereas pure aspirin has a sharp melting point of 136°C.

Section 3: Formulations

Formulations are important in the pharmaceutical industry and are made by mixing the components in **carefully measured quantities** to ensure that the product has the **required properties**.
When you buy a product, the ratio or percentage of each component is found on the packaging. This is its formulation.
Depending on the purpose of the product, the amount and type of chemicals used will be changed to make sure it is right for the job. E.g. Pigment of paint.

Section 4: Paper Chromatography

Chromatography is a physical method that is good for **separating and identifying** things. Chromatography always involves two phases, a **mobile** phase and a **stationary** phase.
In **paper chromatography,** the **mobile phase** is the **solvent**, the **stationary phase** is the **paper**.
During chromatography, the substances in the sample constantly move between the mobile and the stationary phase – an **equilibrium is formed between the two phases.**
A substance which has **stronger attraction** to the stationary phase will **not move very far up the paper** in the same time.
A substance which has **stronger attraction (solubility)** to the **mobile phase** will spend more time in the mobile phase and hence **move further up** the paper.
Different compounds have **different R_f** values in **different solvents**, which can be used to help identify the compounds.



The R_f value can be calculated using the formula:

$$R_f = \frac{\text{distance moved by substance}}{\text{distance moved by solvent}}$$

For substance **P** $R_f = \frac{3}{6} = 0.5$

For substance **Q** $R_f = \frac{4}{6} = 0.67$

Explaining how different dyes are separated using paper chromatography: Solvent (mobile phase) moves through the paper (stationary phase). Different dyes have different solubilities in solvent and different attractions for the paper and hence are carried different distances.

Section 5: Testing for gases

Gas	Procedure	Positive result
Hydrogen	Hold a **lighted splint** at the end of a test tube producing the gas.	The lighted splint **"pops"**.
Oxygen	Hold a **glowing splint** in a test tube of the gas.	The glowing splint **"relights"**.
Carbon dioxide	Bubble gas through a solution of **limewater**.	The limewater turns **"milky"**.
Chlorine	When damp litmus paper is put into chlorine gas	The litmus paper is **"bleached"** and **turns white**.

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Chemistry Topic 13
The Earth's atmosphere

ORGANISER

Section 1: Key terms

Acid rain	**Rain** made so **acidic** that it **causes harm** to the **environment**.
Atmosphere	The **thin** layer of gases **that surround** planet **Earth**.
Biofuels	A source of **renewable** energy made from **plant material** that **absorbs carbon dioxide during photosynthesis**. When it **burns** it **returns** the **same amount** of **carbon dioxide** into the atmosphere.
Carbon footprint	The carbon footprint of a product, service or event is the total **amount of carbon dioxide** and other greenhouse gases **released** over its complete **life cycle**.
Climate change	The **change** in **global weather** patterns that could be **caused** by excess amounts of **greenhouse gases** in the atmosphere.
Ecosystems	A large **community** of **living organisms** in a particular area.
Fossil fuels	Fuels such as coal, oil or natural gas **formed from** the **remains** of **decaying plants** and **animals**.
Global dimming	A decrease in the amounts of sunlight reaching the surface of the Earth.
Global warming	Gradual **heating** of the **Earth** due to increased levels of **greenhouse gases.**
Haemoglobin	A red pigment located in red blood cells **responsible** for **transporting oxygen** around the body.
Longwave radiation	The **radiation emitted from the Earth's surface**. Some is **absorbed** by greenhouse gases and **doesn't escape the atmosphere** (e.g. IR).
Non-renewable	Something which **cannot be replaced** once it is **used** up.
Particulates	Very **small particles** in the atmosphere given off by incomplete combustion of fuels.
Pollutant	A substance that causes **harm** to **the environment**.
Photosynthesis	The process by which plants make food using carbon dioxide, water and sunlight. **Releases oxygen** as a waste product.
Sedimentary rock	When plants, plankton and marine animals die and fall to the seabed, they get laid down in layers. Over time, these layers are squashed under more layers of sediment (sand, mud and pebbles) forming sedimentary rock. Limestone & coal are example of sedimentary rocks.
Shortwave radiation	The **radiation from the Sun**. Is able to **pass through the Earth's atmosphere** and **warm the surface** of the Earth **without being absorbed** by greenhouse gases (e.g. Ultraviolet radiation)

Section 2: History of our atmosphere

Earth's early atmosphere

Early atmosphere is mainly **carbon dioxide** and little or no oxygen gas.

↓

Volcanoes release **nitrogen** , **water vapour** and small amounts of methane and ammonia.

↓

The Earth begins to cool, **water vapour condenses** and forms the **oceans.** Some **carbon dioxide dissolves in** the **oceans**. **Carbon dioxide** is also **locked in fossil fuels** and **sedimentary rocks**.

↓

Green **plants & algae evolve** and **release oxygen** through **photosynthesis**.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

$$\text{carbon dioxide} + \text{water} \xrightarrow{\text{light}} \text{glucose} + \text{oxygen}$$

This process takes in more **carbon dioxide**.

Section 3: Formation of coal, oil, gas and limestone

Coal	**Plants absorbed CO_2.** They **died and decayed**. This layer of decaying plants was **compressed** to form **coal**.
Oil and natural gas	**Plankton absorbed CO_2.** Plankton died and were **deposited in muds on the sea floor**. They were covered over by sediments and **compressed over millions of years**.
Limestone	**Skeletons & shells (containing calcium carbonate)** of dead **marine animals** build up on seabed. They were covered over by sediments and **compressed over millions of years**.

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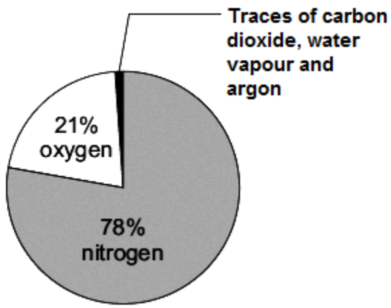
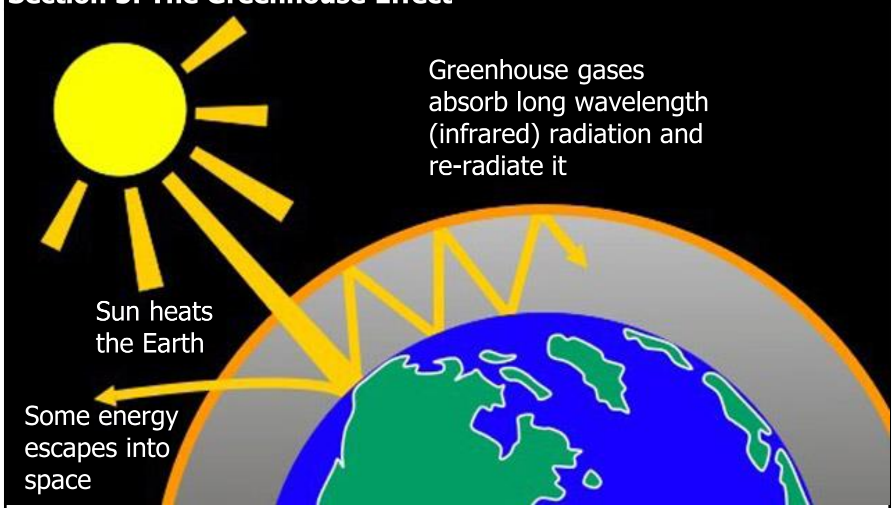
Section 4: The atmosphere today

Nitrogen 78%	
Oxygen 21%	
Argon 0.9%	
Carbon dioxide 0.04%	
Trace amounts of other gases	



Section 5: The Greenhouse Effect



- Greenhouse gases (like carbon dioxide, methane and water vapour act like an **insulating layer** in the Earth's atmosphere.
- They keep the Earth **warm enough** to **support life**.
- Greenhouse gases **don't absorb short wavelength** radiation from the Sun but they **do absorb long wavelength** radiation (**infrared** or thermal radiation) reflected from the Earth.
- They **re-radiate** it back towards the Earth warming the Earth's surface.

Section 6: Global climate change

How humans increase carbon dioxide in the atmosphere	How humans increase methane in the atmosphere
Combustion of **fossil fuels**	Increased **animal farming**
Deforestation	**Rice fields**
	Decomposition of **rubbish in landfill**

How humans can decrease carbon dioxide concentration	How humans can decrease methane concentration
Use **alternative forms of energy** e.g. wind turbines, solar panels	Alternative foods **– non-animal based**
Energy efficiency e.g. more efficient cars e.g. electric cars	Increased **recycling**
Carbon capture – capturing CO_2 from power stations and trapping it underground in porous rocks.	
Carbon off-setting – planting **more trees**	

Effects of global warming
Some regions will **not** be able to produce **enough food** due to **drought**.
Changes to distribution of species and migration patterns put ecosystems under stress.
Rising sea levels because of melting of polar ice caps.
Increasing **common extreme weather** events such as severe storms.

Section 7: Common Pollutants

Pollutant		Cause	Effect
Carbon monoxide	CO	**Incomplete combustion** of a **hydrocarbon** fuel.	**Toxic** gas. Colourless and odourless so hard to detect.
Sulfur dioxide	SO_2	**Burning coal or petrol**. Both contain sulfur which reacts with oxygen in air.	Cause **respiratory problems** (e.g. for those with asthma). Combine with water vapour to cause **acid rain**.
Nitrogen oxides	NO_x	In **car engines**. **N_2** and **O_2 from air** react at **high temperatures**.	
Particulates	C	**Incomplete combustion** of a hydrocarbon fuel.	**Global dimming** (reduction in sunlight reaching Earth). Can damage cells in lungs.

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Chemistry Topic 14
The Earth's resources

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Section 1: Key Terms

Finite resource	A **non-renewable** resource used by humans that has a **limited supply** e.g. coal.
Renewable resources	A resource used by humans that can be **replenished** e.g. trees. If not managed correctly, the resource may decrease.
Potable water	Water that is **safe to drink**. Has **low levels of dissolved salts** and **microbes**.
Fresh water	Water that has **low levels of dissolved salts**. Rain water is an example of fresh water but sea water is not.
Pure water	**Only** contains **water molecules**, nothing else.
Desalination	A process that **removes salt from sea water** to create potable water. **Expensive** as it **requires a lot of energy**.
Sewage	**Waste water produced by people**. Contains potentially dangerous **chemicals** and large numbers of **bacteria**.
Reverse osmosis	Uses **membranes** to **separate dissolved salts** from **salty water**.
Natural resource	Natural resources have **formed without human imput**, includes anything that comes from the earth, sea or air (e.g. cotton).
Synthetic resource	Synthetic resources are **man made**.

Section 2: Natural products that are supplemented or replaced by agricultural and synthetic products

Natural resources	Use	Alternative synthetic product
Wool	Clothing, carpets	Acrylic fibre, polypropene
Cotton	Clothing, textiles	Polyester
Silk	Clothing	Nylon
Wood	Construction	PVC, composites.

Section 3: Finite and renewable resources

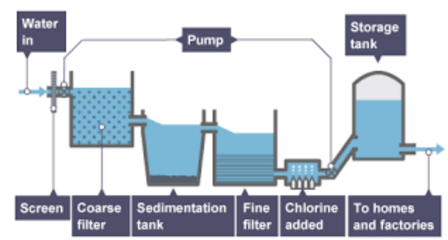
Finite resources	Renewable resources
Metal ores	Trees
Crude oil	Fresh water
Limestone	Food

Section 4: Water safe to drink
Section 4a: Potable water

Providing people with potable water (fresh water) is a major issue around the world. The way that potable water is **produced** depends on **where you are**.

Obtaining potable water in countries with plentiful fresh water e.g. the UK

- Find a suitable source of fresh water (e.g. **lakes, reservoirs, rivers or groundwater aquifers**).
- **Filtration**: Pass through **filter beds to remove large particles** (leaves, twigs etc).
- **Sterilise** to kill microbes (bacteria) e.g. by using **chlorine**, **ozone** or **ultraviolet light**.



Obtaining potable water in countries with limited fresh water

In **dry countries** (e.g. Spain, Kuwait) there's **not enough surface or ground water**, so **seawater** must be treated by **desalination**. Two processes can be used, **distillation** or **reverse osmosis**. Both processes **needs lots of energy** so are **very expensive**.

Distillation:
- Water is heated to **100^{o}C**.
- It **evaporates**, leaving the salt behind.
- A **condenser cools** the water to return it to the liquid state.

Reverse osmosis:
- **Pressure** is applied to the water.
- The **water molecules** move through the **partially-permeable membrane**.
- **Other particles are too large** and are not able to move through.

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Chemistry Topic 14 The Earth's resources

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Section 4b: Sewage Treatment

Sewage treatment requires more processes than **desalination** but **uses less energy** so could be used as an alternative in areas with little fresh water.

Screening	**Removes rags, paper, plastics** and grit that may block pipes.
Sedimentation	Allowed to **stand** in a sedimentation tank so that **suspended particles settle out** of the water an fall to the bottom of a sedimentation tank to **form** the **sewage sludge**. Lighter **effluent** floats on top.
Aerobic digestion of **effluent**	Effluent separated and **air pumped** through encouraging **aerobic bacteria** to break down any **organic matter** including other microbes.
Anaerobic digestion of sewage **sludge**	**Bacteria digest the sludge** in the **absence of oxygen**. This breaks it down. **Methane and carbon dioxide are produced** by the bacteria.
Sterilisation	If the river is a sensitive ecosystem, then the water is filtered one more time and **sterilised** by **UV light** or by **chlorine**.

Section 5: More Key Terms

Aerobic	With oxygen
Anaerobic	Without oxygen
Sustainable development	Using resources to meet the needs of people today without preventing people in the future from meeting theirs.
Life cycle assessment	A life cycle assessment looks at every stage of a product's life to assess the impact it would have on the environment.
Subjective judgement	Judgement based on a person's opinion and/or values.
Phytomining	Plants are used to absorb metal compounds from the soil as part of the metal's extraction.
Bioleaching	Use of bacterial to convert metal compounds in ores into soluble metal compounds which can then be extracted.
Leachate	A solution produced from bioleaching.

Section 6: Alternative Methods of Metal Extraction (HT)

The Earth's resources of metal ores are limited. Copper ores are becoming scarce and new ways of **extracting copper** from **low-grade ores** include **phytomining**, and **bioleaching**. These methods avoid traditional mining methods of digging, moving and disposing of large amounts of rock.

Bioleaching	Phytomining
Bacteria grow on **low-grade copper ores**. They produce a **leachate** (liquid) that **contains soluble copper compounds**.	**Plants** are grown on **low-grade copper ores**. The plants **absorb the copper** and are then **burned**. The **ash** contains **soluble copper compounds**.

The **soluble copper compounds** produced in both methods above can then be extracted by **electrolysis** or **displacement using scrap iron** (as Iron is more reactive than copper).

Section 7: Life Cycle Assessments LCA

Life Cycle Assessment	Life cycle assessments **assess the environmental impact** of **products**. A LCA assesses the use of **water, resources, energy sources** and **production of some wastes** during the following stages: • **extracting** and **processing raw materials** • **manufacturing** and **packaging** • **use** and operation during its lifetime • **disposal** at the end of its useful life (recycling, landfill or incineration) including transport & distribution at each stage. However assigning numerical values to the relative effects of pollutants involves **subjective judgements** and LCA can be **biased** as they can be written to give them deliberate positive advertising.
Reuse	The **environmental impact** of products can be **reduced** by reusing the product. E.**g. glass bottles** can be crushed and melted to produce different glass products.
Recycling	Some materials can be recycled e.g. metals. Metals can be **recycled by melting and recasting** or **reforming into different products**. **Recycling** uses less energy than mining and extracting.