Knowledge Organiser: GCSE – C4 Chemistry; Chemical Calculations

Conservation of Mass

No atoms can be created or made during a chemical reaction, so the mass of the reactants will equal the mass of the product.

Reactions can be shown as a word or symbol equation.

magnesium + oxygen → magnesium oxide

$Mg + O \rightarrow MgO$

Symbol equations should also be balanced; they should have the same number of atoms on each side.

$\mathbf{2Mg + O_2 \rightarrow 2MgO}$

Relative Formula Mass

The relative formula mass (M_r) is the sum of all the relative atomic masses (A_r) of the atoms in the formula.

Examples:

HCl

A_r of H = 1

A_r of Cl = 35.5

M_r of HCl = 1 + 35.5 = 36.5

$\mathbf{H_2SO_4}$

A_r of H = 1

A_r of S = 32

A_r of O = 16

M_r of H_2SO_4 = (1 × 2) + 32 + (16 × 4)

M_r of H_2SO_4 = 2 + 32 + 64

M_r of H_2SO_4 = 98

Calculating Percentage Mass of an Element in a Compound

percentage mass of an element in a compound =

$$A_r \times \frac{\text{number of atoms of that element}}{M_r \text{ of the compound}}$$

Find the percentage mass of oxygen in magnesium oxide.

A_r of magnesium = 24 A_r of oxygen = 16

M_r of MgO = 24 + 16

= 40

$$\% \text{ mass} = \frac{A_r}{M_r} = \frac{16}{40} = 0.4 \quad 0.4 \times 100 = 40\%$$

Conservation of Mass

Show that mass is conserved in a reaction.

$2Mg + O_2 \rightarrow 2MgO$

$(2 \times 24) + (2 \times 16) \rightarrow 2(24 + 16)$

$48 + 32 \rightarrow 2 \times 40$

$80 \rightarrow 80$

Total M_r on the left-hand side of the equation is the same as the M_r on the right-hand side.

Calculate the mass of the product.

6g of magnesium reacts with 4g of oxygen:

6 + 4 = 10g of magnesium oxide

During a reaction the mass can change. If one of the reactants is a gas, the mass can go up.

E.g.

magnesium + oxygen → magnesium oxide

Oxygen from the air is added to the magnesium (making the product) which will be heavier in mass.

If one of the products is a gas, the mass can go down.

E.g.

sodium carbonate → sodium oxide + carbon dioxide

When sodium carbonate is thermally decomposed, carbon dioxide gas is produced and released into the atmosphere.

Concentration of Solutions

Concentration is the amount of a substance in a specific volume of a solution. The more substance that is dissolved, then the more concentrated the solution is.

It is possible to calculate the concentration of a solution with the following equation:

concentration (g/dm^3) = mass (g) ÷ volume of solvent (dm^3)

The equation can be rearranged to find the mass of the dissolved substance:

mass (g) = concentration (g/dm^3) × volume (dm^3)

Limiting Reactions

If one reactant gets used up in a reaction before the other, then the reaction will stop. The reactant that has been used up is limiting.

If you halve the amount of reactant then the amount of product will also be halved.

Leave blank to allow students to glue.

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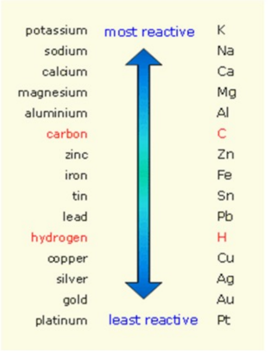
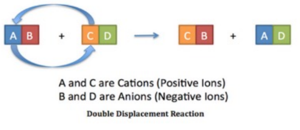
Term	Topic/s	Year group
1	C4	11

Tier 2 'unlocking' language	Tier 3 subject relevant language
Mass	Relative Formula Mass
Balanced	Conservation
Equation	Concentration
Concentration	Limiting Reactants
Calculate	Composition
Solution	Mole
Percentage	Avagadro
Element	Solute

Knowledge Organiser: GCSE – C5 Chemistry; Chemical Changes



Reactivity depends on tendency to form metal ion



HT: OILRIG
Oxidation **I**s **L**oss of electrons
Reduction **I**s **G**ain of electrons

Metal + Oxygen → Metal Oxide

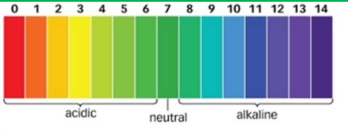
Metal + Water → Metal Hydroxide + hydroge

Metal + acid → Metal salt + Hydrogen

Acid+metal → salt + hydrogen
Acid + alkali → salt + water
Acid + insoluble base → salt + water
Acid + carbonate → salt + water + carbon dioxide

HT: OILRIG
e.g. $2HCl + Mg \rightarrow MgCl_2 + H_2$
Magnesium is oxidised
$Mg \rightarrow Mg^{2+} + 2e^-$

Hydrochloric Acid → Chlorides
HCl
Nitric Acid → Nitrates
HNO_3
Sulphuric Acid → Sulphates
H_2SO_4



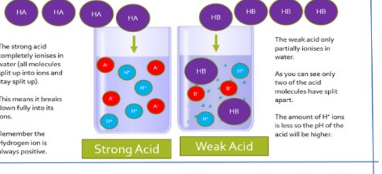
Acids produce H^+ ions
Alkalis produce OH^- ions

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

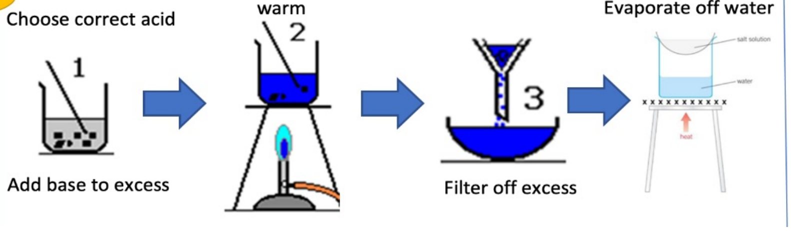
HT: Strong and Weak acids

Concentration of hydrogen ions in mol/dm³	pH
0.10	1.0
0.010	2.0
0.0010	3.0
0.00010	4.0

Strong and weak acids



RP: Preparation of a dry sample of a soluble salt



Reactivity series	An arrangement of metals in order of reactivity
Displacement reaction	Reaction where a more reactive element takes the place of a less reactive element in a compound
Oxidation	A reaction in which a substance loses electrons (gains oxygen)
Reduction	Reaction in which a substance gains electrons (loses oxygen)
Ore	A rock from which a metal can be extracted for profit
Acid	Solution with a pH less than 7; produces H^+ ions in water
Alkali	Solution with a pH more than 7; produces OH^- ions in water
Aqueous	Dissolved in water
Strong acid	Acid in which all the molecules break into ions in water
Weak acid	Acid in which only a small fraction of the molecules break into ions in water
Dilute	A solution in which there is a small amount of solute dissolved
Concentrated	A solution in which there is a lot of solute dissolved
Neutralisation	A reaction that uses up some or all of the H^+ ions from an acid
Electrolysis	Decomposition of ionic compounds using electricity
Electrolyte	A liquid that conducts electricity
Discharge	Gain or lose electrons to become electrically neutral
Inert electrodes	Electrodes that allow electrolysis to take place but do not react themselves

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Balanced	Conservation
Equation	Concentration
Concentration	Limiting Reactants
Calculate	Composition
Solution	Mole
Percentage	Avagadro
Element	Solute

Knowledge Organiser: GCSE – C8 Chemistry; Rates and Equilibrium

Factors which affect Rate of Reaction

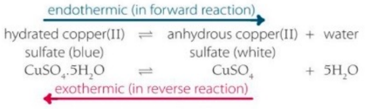
Being able to slow down and speed up chemical reactions is important in everyday life and in industry. We can change the rate of a reaction by:

- Changing temperature
- Changing pressure
- Changing the concentration of a solution
- Changing the surface area
- Adding a catalyst

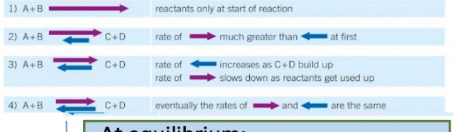
Can go in both directions.

$$A + B \rightleftharpoons C + D$$

If a reaction is exothermic in one direction it is endothermic in the other direction.

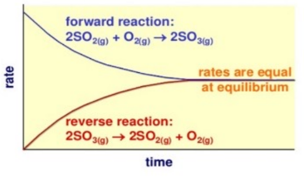


In a **closed system** (where nothing can get in or out) an **equilibrium** is reached where the **rate of reaction is the same in both directions.**

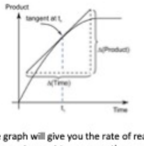


At equilibrium:

- Rate of forward reaction = rate of reverse reaction.
- Mount of products and reactants don't change.



Measuring Rate of Reaction-Higher Tier

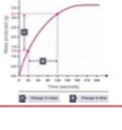


The gradient of a volume or mass/time graph will give you the rate of reaction at a given point. However when the line is a curve you need to draw **a tangent** to measure the gradient. To draw a tangent follow the following steps

1. Line you ruler up across your graph, so that it touches the line on the point that you want to find out the gradient
2. Adjust the ruler until the space between the ruler and the curve is equal on bothsides
3. Draw the line and pick two easy pints that will allow you to calculate the gradient of the line.

Calculating the Mean Rate of Reaction -Higher Tier

To calculate the mean rate of reaction from a graph you need to pick two y values on the graph and two x values, subtract the largest from the smallest and the divide the value on the y axis by the valued on the x axis.



Changing Conditions-Le Chatelier's principle- Higher Tier

The Haber process is a good example to explain Le Chatelier's principle, the equation for the Haber process is shown below. The reaction is carried out in the gaseous state. Remember this is one of many reactions but the principles always stay the same.

Endothermic in this direction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ Exothermic in this direction

Condition Change	Effect
Increase the temperature	Shifts the equilibrium to the left as this is the endothermic direction. The amount of reacrtants increases.
Decrease the temperature	Shifts the equilibrium to the right as this is the exothermic direction. The amopunt of product increases
Increase the concentration of reactants	Equilibrium shifts to the right to make more product, to reach equilibrium again
Increase the concentration of products	Equilibrium shifts to the left to reach equilibrium again
Increase the pressure in the gas	Equilibrium shifts to the right, where there are fewer molecules of gas, this will decrease the pressure.
Decrease the pressure in the gas	Shifts the equilibrium to the left as there are more gas molecules on that side of the equation.

Key Terms	Definitions
Equilibrium	A reaction that is reversible
Le Chatelier's principle	A principle which states, "If a system is at equilibrium and a change is made to any of the conditions, then the system responds to **counteract the change**"
Dynamic Equilibrium	An equilibrium where the forward and backward reactions are happening at the same rate

Equilibrium- Changing Conditions-Higher tier

The amounts of all the reactants and products at equilibrium depend on the conditions of the reaction. For example if we change things like **temperature, concentration of a reactant or product and pressure in gases.**

The French scientist Le Chatelier devised a principle to explain how equilibrium reactions, respond to a change in conditions, it states that:

"If a system is at equilibrium and a change is made to any of the conditions, then the system responds to counteract the change"

For example if the temperature is raised the equilibrium will shift to try to cool the surroundings down.

Leave blank to allow students to glue.

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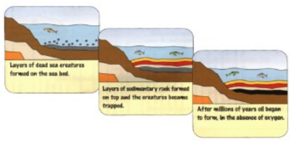
Term	Topic/s	Year group
1	C8	11

Tier 2 'unlocking' language	Tier 3 subject relevant language
Frequency	Le Chatelier's Principle
Collisions	Catalyst
Volume	Equilibrium
Concentration	Neutralisation
Temperature	pH
Pressure	Ions
Energy	Activation energy
Rate	Reaction Profile

Knowledge Organiser: GCSE – C9 Chemistry; Organic Chemistry

Episode 1 - Hydrocarbons

Crude Oil is made from the remains of living **sea creatures** decayed in mud millions of years ago

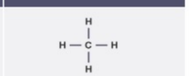
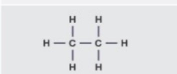
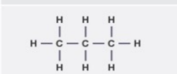
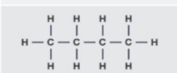


It is a **FINITE** resource

It is made of a mixture of Hydrocarbons.

Hydrocarbons are made of **Hydrogen and Carbon only.**

The main hydrocarbons in Crude Oil are **alkanes**

Alkane	Molecular formula	Structural formula
Methane	CH_4	
Ethane	C_2H_6	
Propane	C_3H_8	
Butane	C_4H_{10}	

The general formula for an alkane is -

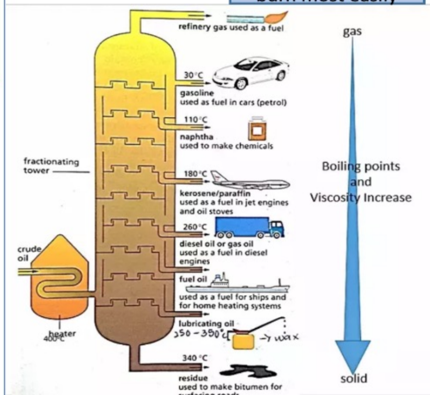
C_nH_{2n+2}

Episode 2 - Fractional Distillation

How do we separate the mixture of hydrocarbons to use them?

Works by **evaporation** and then **condensation.**

Smaller molecules burn most easily



1. **Heat** the crude oil to **evaporate** it.
2. The gases **rise** up the column.
3. The different fractions **condense** at **different temperatures.**

Episode 3 - Combustion

Combustion (burning) is a reaction with **oxygen**

A reaction with oxygen is called **'oxidation'**

When hydrocarbons burn a lot of **energy** is released.

Complete combustion of hydrocarbons the only products are **carbon dioxide and water**

Complete combustion only happens if there is plenty of oxygen

General equation

hydrocarbon + oxygen → carbon dioxide + water

Complete combustion of propane

propane + oxygen → carbon dioxide + water

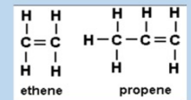
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

Episode 4 - Cracking

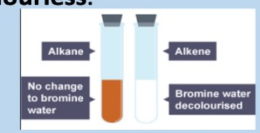
The larger molecules from fractional distillation are less useful. We can break them down into smaller, more useful molecules.

Cracking produces a mixture of **alkanes and alkenes.**

Alkenes have **some double bonds.**

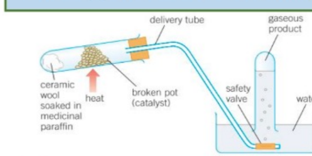


They turn **bromine water colourless.**



They are used to make **polymers.**

The apparatus for cracking



Catalytic cracking – catalyst and 500°C

Steam cracking – steam and 850°C

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Term	Topic/s	Year group
2	C9	11

Tier 2 'unlocking' language	Tier 3 subject relevant language
Organic	Fractional
Property	Distillation
Cracking	Alkane/ene
Property	Homologous Series
Fraction	Viscosity
Fossil Fuel	Volatility
Column	Hydrocarbon
Combustion	Saturated

Knowledge Organiser: GCSE – C10 Chemistry; Chemical Analysis

Key Points	
Pure substance	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 changes state from a solid to a liquid.
Boiling point	The **temperature** at which a substance changes state from a liquid to a gas.
Chromatography	An analytical method used to **separate substances** in a **mixture**.
Mixture	A mixture is not a pure substance. It consists of two or more elements/compounds not chemically combined.

Pure substances and mixtures

You can use melting points and boiling points to identify pure substances. For example, the **test for pure water** is that it melts at exactly 0°C and boils at exactly 100°C.

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.

Formulations

Formulations are made by mixing components in **carefully measured quantities** to ensure that the product has the **required properties**.

Depending on the product's intended function, the amount and type of chemicals used will be changed to make sure it is right for the job. E.g. Pigment of paint.

Testing for gases

Gas	Method	Positive test
Hydrogen	Hold a **lighted splint** at the end of a test tube producing the hydrogen gas.	The lighted splint gives a squeaky **"pop"**.
Oxygen	Hold a **glowing splint** in a test tube of the oxygen gas.	The glowing splint **"relights"**.
Carbon dioxide	Bubble carbon dioxide gas through a solution of **limewater**.	The limewater turns **"milky or cloudy"**.
Chlorine	When damp litmus paper is put into test tube containing chlorine gas	The litmus paper is **"bleached"** and **turns white**.

Paper Chromatography

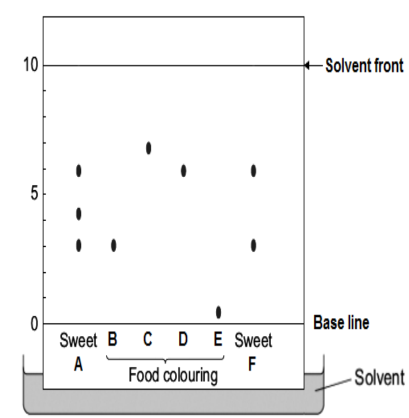
Chromatography always involves two phases, a **mobile** phase and a **stationary** phase.

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 forming an equilibrium.

Different dyes have different solubilities in solvent and different attractions for the paper and hence are carried different distances. An unknown substance can be identified by calculating its R_f value.

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



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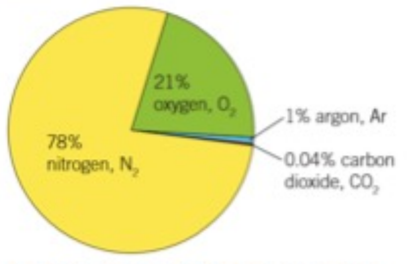
Knowledge Organiser: GCSE – C11 Chemistry; The Earth's Atmosphere

What is the atmosphere?

The air around us is called the **atmosphere**. The atmosphere is a mixture of gases that surrounds the Earth. It is mainly two elements, nitrogen and oxygen. There are smaller amounts of other substances, including carbon dioxide and argon.



▲ The most common substances in the Earth's atmosphere, by volume.

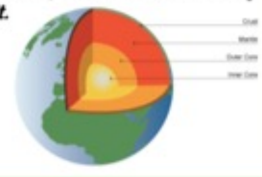
Earth Structure

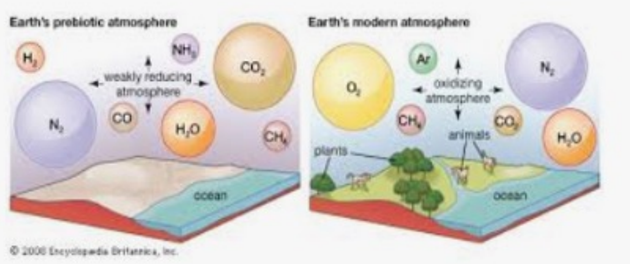
Inner Core: Solid iron and nickel

Outer core: Liquid layer of iron and nickel

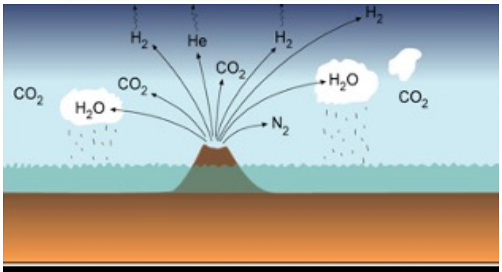
Mantle: classed as a liquid.

Crust: Land is made of **continental crust**, made mostly from ***granite***. The layer beneath the ocean bed is made of **oceanic crust**, which is made mainly from ***basalt***.





Comparison of Earth's prebiotic and modern atmospheres. Before life began on the planet, Earth's atmosphere was largely made up of nitrogen and carbon dioxide gases. After photosynthesizing organisms multiplied on Earth's surface and in the oceans, much of the carbon dioxide was replaced with oxygen.



There are two competing theories. 1. that Earth's water might have been captured from asteroids and comets that collided with the planet. 2.Tthat water was always present in the rocks of the Earth's mantle and was gradually released to the surface through volcanoes.

Fossil fuels

Coal, oil, and gas are **energy resources** that were formed millions of years ago. That is why they are called **fossil fuels**. Oil and gas are made from the fossilised remains of sea creatures. Coal is the fossilised remains of trees.

Coal, oil, and gas are **non-renewable**. That doesn't mean that you can't use them again. It means that you cannot easily get more of them when we have used them up.

Causes and Effects of Climate Change

Causes

- Rapid industrialization
- Energy use
- Agricultural practices
- Deforestation
- Consumer practices
- Livestock
- Transport
- Resource extraction
- Pollution

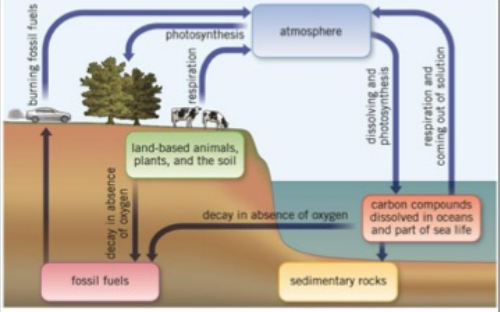
Effects

- Rising temperatures
- Rising sea levels
- Unpredictable weather patterns
- Increase in extreme weather events
- Land degradation
- Loss of wildlife and biodiversity

What are the social impacts of climate change?

Displaced people. Poverty. Loss of livelihood. Hunger. Malnutrition. Increased risk of diseases. Global food and water shortages.

Carbon Cycle



▲ The carbon cycle.

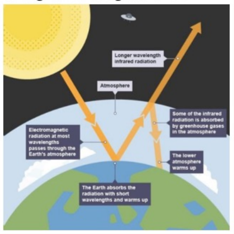
The Greenhouse Effect

The Earth has a layer of gases called the **Greenhouse layer.** These gases, which include carbon dioxide, methane and water vapour**,** maintain the temperature on Earth high enough to support life.

The greenhouse layer allows the short wave infrared radiation emitted by the Sun to pass through it but absorbs the long wave infra red radiation which is emitted by the Earth. This is how it insulates the Earth.

Some human activities increase the amounts of greenhouse gases in the atmosphere. These include:

- combustion of fossil fuels
- deforestation
- methane release from farming
- more animal farming (digestion, waste decomposition)



Elements - only one type of atom in the particle

78% nitrogen N_2 molecules (about 80% or $^4/_5$ths) N_2 important to plants if not of direct use to us!

21% oxygen O_2 molecules (about 20% or $^1/_5$th), rather important for respiration!

1% argon **Ar** atoms ($^1/_{100}$th), plus traces of other Group 0 Noble Gases (He, Ne, Kr, Xe atoms)

Leave blank to allow students to glue.

How do we use Knowledge Organisers in Chemistry

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Term	Topic/s	Year group
2	C13	11

Tier 2 'unlocking' language	Tier 3 subject relevant language
Atmosphere	Greenhouse
Gases	Evolution
Million	Enhanced
Changes	Consequences
Life	Emitted
Absorb	Desalination
Combustion	Effluent
Human Activity	Vapour

Knowledge Organiser: GCSE – C12 Chemistry; The Earth's Resources

Episode 1 - Finite and Renewable

What do the words mean??

Finite = Will run out eventually
Renewable= We can replace them as we use them
Sustainable = meets the needs the current generation without compromising he ability of future generations to meet their needs.

What do we use the earth's resources for?

- **Warmth**
- **Shelter**
- **Food**
- **Transport**

We can use them as natural resources or process them.

'Natural resources' + agriculture provides

- **Food**
- **Timber**
- **Clothes**

Finite resources are processed to get us

- **Energy**
- **materials**

e.g. Cotton is natural and we grow cotton plants. OR we can use synthetic materials e.g. nylon

e.g. Coal, oil and gas are used for energy.
e.g. metal ores are mined to get metals.

Episode 2 - Treating water

Potable water must have low levels of SALTS and MICROBES (it isn't PURE water)

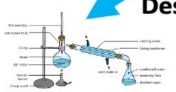
Rainwater in lakes, rivers and reservoirs → **Filter** → (Why? To remove insoluble solids) → **Sterilise – chlorine, ozone, or UV light** (Why? To kill microbes)

Sewage → **Screening and grit removal** → **Sedimentation** → **Anaerobic digestion of sludge** / **Aerobic treatment of effluent**

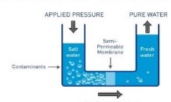
Industrial and agricultural waste water – remove organic matter and harmful chemicals

Salt water

Desalination



Distillation



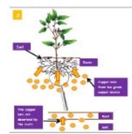
Reverse osmosis

☹ Both use a lot of energy

Episode 3 - Alternative Metal Extraction

Why bother?
Running out of metal ores

Phytomining



Plants take in copper

- BURN plants
- React ASH with sulphuric acid

Bioleaching

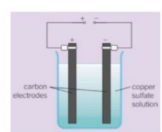
Bacteria feed on metal ore

- 'leachate solution' contains copper compounds

How to get the copper from the compound

Displacement using scrap iron

Electrolysis



Episode 4 - LCA and RRR

Life Cycle Assessments

Water
Resources
Energy sources

Waste

Reducing use of resources

Why bother?
Reduce…use of limited resources

Why bother?
Reduce…use of energy resources

Why bother?
Reduce…waste and environmental impacts

mining

landfill

Leave blank to allow students to glue.

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2	C14	11

Tier 2 'unlocking' language	Tier 3 subject relevant language
Ore	Purification
Resources	Sedimentation
Mining	Bioleaching
Finite	Phytomining
Pure	Comparative
Sewage	Incineration
Recycle	Sterilising
Reuse	Sustaining