09.1 CHEMICAL REACTIONS.KO.2022-23

Chemical reactions

How do we know a chemical reaction has happened?

- Gases given off
- colour changes,
- precipitates(solids) forming
- temperature changes

Conservation of mass

In a chemical reaction the total mass of the reactants will equal the total mass of the products

Reactivity



When metals react they form positive ions and their reactivity relates to how easy it is for them to lose their outermost electrons.

You can arrange metals according to their reactivity to give a **reactivity series.** One way to do this is too look at their reactions with acid and water as metals will react in similar ways.

The group 1 metals react with water in the following reaction:

Metal + water→ metal hydroxide + hydrogen

The reactivity increases as you go down group 1. Once you get to group 2 some of the metals towards the top of the group are not reactive enough to react with water so we react them with acid:

Metal + Acid → Salt + hydrogen.

Again reactivity increases as you go down group 2.
Some metals such as zinc and Iron will only react very slowly and others such as copper will not react at all.

Displacement

This happens when a reactive element displaces a less reactive element from its compound.
The following **reactions** are examples of displacement reaction:

Copper sulfate + Iron → Iron sulfate + copper

$CuSO_4 + Fe \rightarrow FeSO_4 + Cu$

In group 7 (non-metals) reactivity decreases as you go down the group.

Potassium + Chlorine → Potassium bromide + Bromine chloride

$2KBr + Cl_2 \rightarrow 2KCl + Br_2$

Extracting Metals

Metals must be extracted from the Earth's crust. The method used to extract the metal depends on its reactivity.

Unreactive Metals

Unreactive metals are found in their elemental form. These are called native metals.

Reactive Metals

Other metals are found as metal oxides and metal carbonates. To get the metals out of the compounds chemical reactions need to take place. If the metal is below carbon on the reactivity series then it is separated by heating the metal compound with carbon to give the metal and carbon dioxide.

Metals above carbon in the reactivity series are separated using electrolysis. This uses electricity to separate the substances in the compound. The metal compound is heated until it melts and electricity flows through the molten compound separating the metal from the rest of the compound.

09.1 CHEMICAL REACTIONS.KO.2022-23

Alternative Methods for Extracting Metals

Copper is in high demand and ores (rocks containing enough metal compounds to make it economically viable to extract) are becoming scarce.

Traditional methods are expensive processes due to the energy needs.

Alternative methods:

Phytomining:
Plants (usually brassicas) grown on waste land with low levels of metal compounds. Plants take up the metals and once grown they are cut down, burnt and metals extracted from the ash.
+ cheap, easy, reduces level of toxic metals in soil
- slow

Bioleaching:
Bacteria are sprayed onto piles of waste rock. They 'eat' the minerals releasing the copper/metal compounds and the copper/metal can be extracted from the solution
+ more environmentally friendly then using sulphuric acid on waste rock (older method)
- slow
These produce copper compounds, such as copper sulfate, and the copper is extracted via displacement or electrolysis.

Making Salts.

Metals and acids react to give salt and hydrogen. The salt produced depends on the metal and acid used.
Example:
$Mg_{(s)} + H_2SO_{4(aq)} \rightarrow MgSO_{4(aq)} + H_2$
In this example the Mg is losing electrons to become Mg^{+2} so is oxidised. H^+ is gaining electrons to become H_2 and is being reduced.

Metal is always oxidised and H^+ is always reduced.

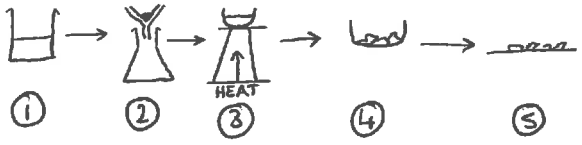
Salts From Insoluble Bases.

Insoluble bases are generally metal oxides and some metal carbonates.

Practical:

1. An acid is added to a beaker and a solid base is added until it no longer reacts. This solution can be warmed to ensure the reaction goes to completion.
2. Once the reaction is complete and the base is in excess then the excess can be removed using filter paper and filter funnel.
3. The filtrate (liquid) is placed into an evaporating basin and warmed until half of the water has evaporated.
4. The evaporating basin is left in a warm place until all the water evaporates.
5. The crystals are dried on some filter paper.

Issues to be aware of:
1. Ensure you select the right acid and base to make the salt you are asked to make
2. The base must be in excess to ensure the acid has completely reacted. If this isn't done, then the crystals will not be pure.
3. Do not boil the filtrate as this may causes unwanted reactions and affect the crystals.

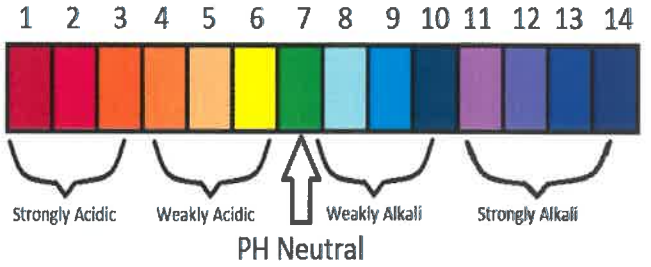


Neutralisation and the pH scale

Acids produce **hydrogen ions (H^+)** in aqueous solutions. Aqueous solutions of **alkalis** contain **hydroxide ions (OH^-).**

The pH scale, from 0 to 14, is a measure of the acidity or alkalinity of a solution and can be measured using universal indicator or a pH probe. A solution with pH 7 is neutral. Aqueous solutions of acids have pH values of less than 7 and aqueous solutions of alkalis have pH values greater than 7.

Universal indicator gives the following colours.



In neutralisation reactions between an acid and an alkali, hydrogen ions react with hydroxide ions to produce water. This reaction can be represented by the equation:

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

(HT) pH is related to the concentration of hydrogen ions. For example, a solution with a pH of 1 has 10 times more hydrogen ions than a solution with a pH of 2 and 100 times more hydrogen ions than a solution with a pH of 3.

09.2 ENERGY AND ENERGY RESOURCES.KO.2022-23

Types of energy

There are many types or forms of energy. Whenever something happens energy gets transferred from one form into another.
By transferred we mean that it has changed from one type of energy to another.
Some types of energy are called energy stores – the energy just sits in an object or place until something happens.

Conservation of energy

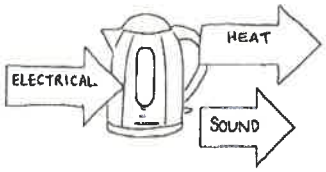
Energy cannot be created or destroyed, only transferred.
Energy is measured in joules, J.

Forms of energy

Magnetic
Kinetic
Heat (Thermal)
Light
Gravitational Potential
Chemical
Sound
Elastic
Electrical
Nuclear

Energy Transfer Diagrams

We can represent using diagrams the energy transfers that take place during some process, whether that be turning on a torch or you are sliding down a slide.
We know that the energy we put into something must be the same as the amount of energy that comes out.

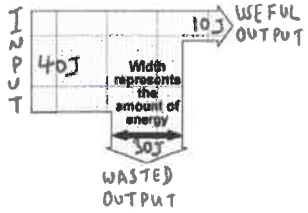


Waste & Useful Energy

Humans have made machines and devices that do useful energy transfers for us.
Unfortunately, we are not able to make devices that transfer all the energy we put into a device into the useful energy we want – there is always some waste energy.
Input, useful and waste energy are easily seen on a ...

Sankey Diagram

These are energy transfer diagrams which are drawn to scale, so you can easily compare the useful output and the wasted output.
These diagrams show the input energy on the left.
They show the waste and useful energy on the right. Usually, the useful output points to the right, whereas the wasted energy usually points downwards.
The numbers on the right must add up to the numbers on the left.

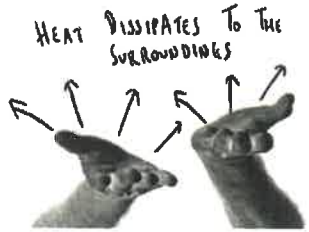


Energy Dissipation

A store of energy does not always stay in one place. Sometimes it will be transferred to the surroundings of an object.

A good example is heat energy. A hot object will pass its thermal energy to the surroundings (which will generally be the air particles around the object), and this will cause the object to cool down. The surroundings will gain heat energy in the form of increased kinetic energy of air particles. This is known as energy dissipation.

You can demonstrate this to yourself by rubbing your hands together quickly, then holding your hands palm upwards. You can feel the heat energy transferring to the air close to your hand.



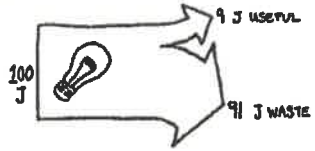
Efficiency

Efficiency is a number.
The bigger the number, the better a device is at transferring energy usefully.
The lower the number the less useful a device is at transferring energy.

Formula

$$\text{Efficiency} = \frac{\text{Useful energy}}{\text{Input energy}}$$

Example



$$\textbf{Efficiency} = \frac{9}{100} = 0.09$$

An efficiency of 0.09 is not very good.
This lightbulb is not efficient.
This light bulb wastes too much energy.

Fuels

A fuel is a substance that contains a store of chemical energy or nuclear energy.
We use this energy released from the fuels to generate electricity in power stations, which can then be transferred around to homes, schools, hospitals, and offices.
Some fuels are also used to make materials like plastic, grease, cosmetics, and tarmac.



Non-renewables or 'Finite'

Non-Renewable or **Finite** fuels cannot be replaced at the rate humans are using them, so eventually we are going to run out. In other words**, non-renewables cannot be replenished** within a **human lifetime**.

Example

Coal takes about 220 million years to form.
The coal we use today was formed millions of human lifetimes ago.
Once we use that coal, we will not be alive when new coal is available.



Coal

When plants died millions of years ago, some of them became buried in mud. This stopped them rotting in the normal way.
Over millions of years more and more layers of mud squashed them together.
With the heat produced from inside the earth, the mud turned into rock and the remains of the plants turned into what we call coal.

Coal can be bad.

Produces pollution.
Produces CO_2 which contributes to global warming and climate change.

Coal can be useful.

There is enough coal to satisfy what we need ***for now.***
Electricity made by burning coal is reliable.



Oil & Gas

When animals and plants that live in the sea die, they sink to the bottom of the sea.
Over millions of years layers of mud & sand fell on top of them and squashed them together.
This increases the pressure and heat on the dead organisms and the mud. The mud & sand turn into sludgy liquid and gas which is trapped between the rock.
We call these oil and gas.

Oil & gas can be bad.

Produces pollution.
Produces CO_2 which contributes to global warming and climate change.
Oil is such a useful product in modern life but could be deemed a waste, just using it to make electricity.

Oil & Gas can be useful.

There is enough oil and gas to satisfy what we need ***for now.***
Electricity made by burning oil and gas is reliable.



Nuclear

Certain rocks in the ground constantly give off energy.
This energy does not come from squashed plants and animals (like coal, oil, and gas) but the rocks do run out if they all get used up.
For this reason, nuclear fuel is called a non-renewable energy source.
Nuclear energy does not require burning in electricity power stations, but it still produces heat.

Nuclear can be bad.

Produces very dangerous radioactive waste that lasts for thousands of human lifetimes.
We still do not know how to deal with it safely for this long a time.

Nuclear can be useful.

Nuclear fuel does not make CO_2, so it does not contribute to global warming and climate change. Electricity made by nuclear power stations is reliable.



09.2 ENERGY AND ENERGY RESOURCES.KO.2022-23

Renewables

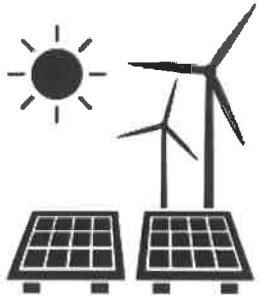
As we are slowly running out of fossil fuels, we need other ways of making electricity and satisfying our fuel needs.
A lot of renewable energy resources rely on nature or the weather which means they are not available to use all the time.

Advantages

- The resources are not depleted (used up)
- They do not damage the planet by producing pollutants.
- They are low maintenance and do not required humans to operate them.

Disadvantages

- Can be unreliable as they depend on the weather.
- They are expensive to build.
- They do not produce as much power as non-renewable.



Solar

Special materials turn sunlight straight into electricity or can use sunlight to heat water.

Advantages

- Is renewable.
- Cheap.
- Does not pollute.
- No CO_2.

Disadvantages

- Only works when it is sunny.
- Only works where it is sunny.
- Not a very concentrated source of energy.



Wind

Wind turns special windmills called turbines that generate electricity.

Advantages

- Is renewable.
- Cheap.
- Does not pollute.
- No CO_2.
- UK has lots of wind.

Disadvantages

- Only works when it is windy.
- Turbines must be turned off when it is too windy.
- Not a very concentrated source of energy.



Water

The up-and-down motion of sea waves is used to turn water turbines to make electricity.

Advantages

- Is renewable.
- Does not pollute.
- No CO_2.
- UK has lots of sea waves.

Disadvantages

- Need huge numbers that take up a lot of space in the sea.
- Not a very concentrated source of energy.
- Very challenging engineering to build them.



Geothermal

Hot rocks in the ground have cold water pumped down to them. This water is allowed back up when it is very hot.
Steam used to heat homes and run electricity power stations.

Advantages

- Cheap.
- Free.
- Does not pollute.
- No CO_2.

Disadvantages

- Only works where there are hot rocks near the Earth's surface (not the UK so much).



Hydro electric

In mountainous places, lakes high up have holes drilled in the bottom to let water out through pipes.
The water moves very fast and turns electricity generating turbines.

Advantages

- Cheap to run.
- Free.
- Does not pollute.
- No CO_2.

Disadvantages

- Expensive to build.
- Only works where there are mountainous lakes.



Work Done

To move an object against a force, energy must be transferred. If you move an object and there is a force acting against you, for example friction, then you have done "work". This is where the phrase "work done" comes from. Like energy, work done is also measured in joules.

In physics, if **you do work** on an object, one of its energy stores will increase. An example of this is the air in a piston. If you compress air (push it into a smaller space), it is temperature increases, so its thermal energy increases. This increase was due to the work done **TO** the gas. The opposite is also true. If **the object does work**, then its energy stores will decrease.

Formula

Work done = force × distance

Example

If you apply a force of 3N to overcome friction and move an object a distance of 5m, the work done would be:

$$\text{Work Done} = 3\text{N} \times 5\text{m} = 15\text{J}$$

Energy and Power

Energy and power are two very closely linked quantities.

Energy can be transferred very quickly. An example is a rocket launch where chemical energy is rapidly transferred into heat, sound, and kinetic energy. Energy can also be transferred quite slowly. An example of this could be a snail slowly moving down a wall. The **rate** of energy transfer (which means the amount of energy transferred in one second), is known as the **power**. Power is measured in watts.

Formula

$$\text{Power} = \frac{\text{energy}}{\text{time}}$$

Example

A battery transfers 200J to a torch in 5 seconds. Calculate the power of this energy transfer:

$$\text{Power} = \frac{200\text{J}}{5\text{s}} = 40\text{W}$$

Biofuel

Bio means living so biofuel literally means fuels that are being grown (plants) or fuels that are produced by living things (manure).
Throughout human history fuels have been traditionally renewable:



Grow
sun's light energy → chemical energy store



Harvest



Burn
chemical energy store → Heat + Light
Chemical energy store of the wood decreases
Thermal energy store of the air increases



Replenish
Grow back within a human lifetime

We can also now chemically turn some crops into vehicle fuels:



Grow Sugar Cane
sun's light energy → chemical energy store



Harvest



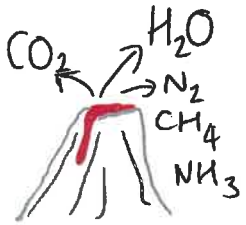
Turned into Fuel
✓ Renewable fuel
✗ Uses up land that food could be grown on
✗ Food prices rise

09.3 HISTORY OF ATMOSPHERE.KO.2022-23

The Earth's Early Atmosphere

Evidence for what made up the Earth's early atmosphere is difficult to fins as the Earth was formed 4.6 billion years ago.

One possible theory suggests that there would have been mainly **carbon dioxide** with little or no oxygen like the atmosphere of Mars and Venus. This would have been produced by intense volcanic activity.



The volcanoes would also produce **nitrogen** and there may have been small amounts **of methane and ammonia.**

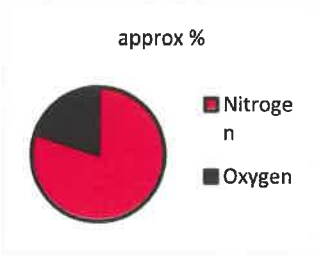


Water vapour from the volcanoes and comets condensed as the Earth cooled and the oceans formed.

The Present-Day Atmosphere

The current levels of gases in the atmosphere has remained constant for around 200 million years.

Currently it is:

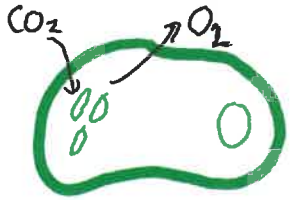


Approx 80% Nitrogen
Approx 20% Oxygen

Small amounts of carbon dioxide, methane and noble gases make up the rest.

When we measure the proportions of the atmosphere, we use dry air. This is where the water vapour has been removed as this can vary depending on where you are and the weather in that location.

How Oxygen Increased (common with BIO)



Algae and photosynthetic bacteria began producing oxygen around 2.7 billion years ago. As the level of oxygen increased the ozone layer formed and eventually plants evolved on land and the amount of oxygen increased to a level where animals evolved.

Photosynthesis:

$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

Carbon dioxide + water → glucose + oxygen

How Nitrogen Levels Changed

Nitrogen has increased over time has it been released into the atmosphere by volcanoes. Over time it has built up to current levels as it is unreactive.

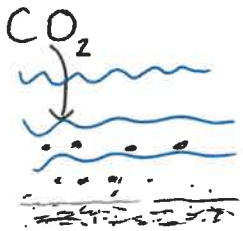
09.3 HISTORY OF ATMOSPHERE.KO.2022-23

How Carbon Dioxide Decreased

The amount of carbon dioxide in the atmosphere was decreased in several ways:

Taken up during photosynthesis – see equation in oxygen section.

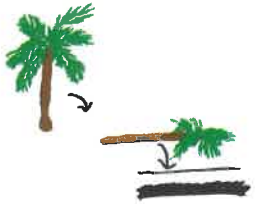
Formation of sedimentary rocks



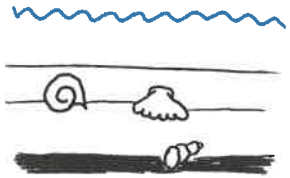
The carbon dioxide dissolved in the ocean and reacted with metal hydroxides to form sediments which sink to the bottom of the ocean and form rocks over time

Algae and plankton absorb carbon dioxide during photosynthesis and the carbon dioxide is locked into biological molecules including calcium carbonate in shells and bones. When the organisms die, they sink to the bottom of the ocean and over time form limestone rocks

Formation of fossil fuels



Coal is formed when plants (which absorb carbon dioxide while alive) die and fall into a swamp. The plant material decays anaerobically (no oxygen) and over time coal is formed. When the coal is burnt it release the carbon dioxide which had been locked inside the plant's molecules

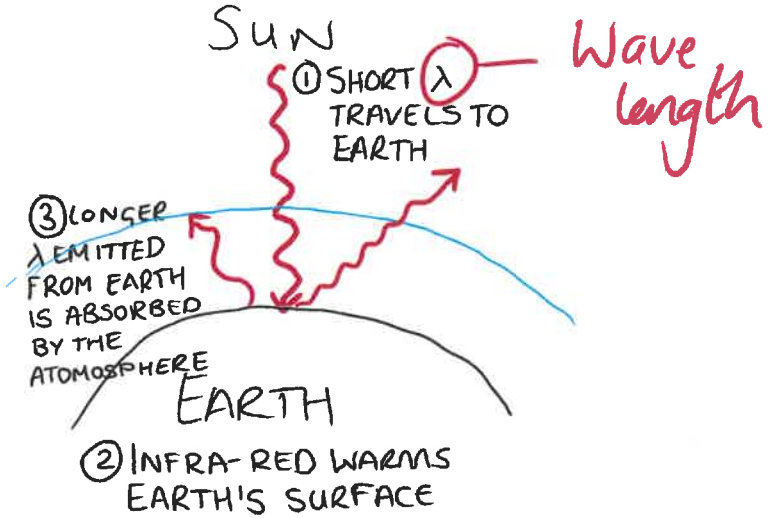


Crude oil is formed in a similar way but is sea creatures which die and sink to the bottom of the ocean, get covered in mud and rock. Overtime the organisms decay anaerobically and form crude oil.

The Greenhouse Effect (common with PHY)

The greenhouse effect is important in maintaining temperatures on Earth high enough to support life.

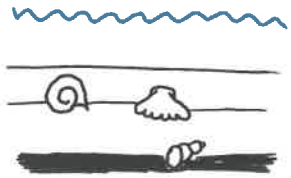
The greenhouses gases can all absorb specific wavelengths of infra-red. The greenhouse gases are **carbon dioxide, methane and water**. The greenhouse effect is important in maintaining temperatures on Earth high enough to support life.



Without the greenhouse effect the average global temperature would be much lower around -18°C.

09.4 CRUDE OIL AND FUELS.KO.2022-23

Crude Oil



Crude oil is a **finite** resource found in rocks. It is a **mixture** of **compounds**. Most of the **compounds** in crude oil are **hydrocarbons**, which are molecules made up of **hydrogen** and **carbon atoms only**. Most of the hydrocarbons in crude oil are called **alkanes**.

- When **animals and plants** in the sea **die**, they **sink** to the bottom of the sea.
- Over **millions of years** layers of mud & sand fell on top of them and **squashed** them together.
- The mud & sand turn into **rock** and the **remains** of the **organisms** turn into **Oil and Gas**.

PETROLEUM & NATURAL GAS FORMATION



Structure of Hydrocarbons

There are two types of hydrocarbons. **Alkanes** have the formula C_nH_{2n+2}. **Alkenes** have the formula C_nH_{2n}. **Alkanes** have **only single bonds** and **alkenes** have at **least one double bond** we are going to focus on alkanes.

Prefixes and suffixes

The **hydrocarbons** are **named** following specific rules.

The **prefixes** of all hydrocarbons **rely** on the **number** of **carbons** in their **chain**. The **suffix** for **alkanes** is always **-ane**.

Below are the first four prefixes:

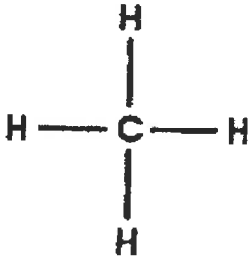
1 carbon= **meth-** **2** carbons= **eth-** **3** carbons= **prop-** **4** carbons= **but-**

After this, the prefixes **follow** the **same pattern** as **naming shapes** in maths. For example, a pentagon has five sides, an **alkane** with **5 carbons** will have the prefix of **pent-** and as an alkane will have the suffix **-ane** making it **Pentane**.

Representing the structure of a hydrocarbon.

Hydrocarbons can be represented by **writing** the **formula** or by **drawing** the **structure.** For example: **methane**, It has **1 carbon** and **4 hydrogens**. Therefore, we write it as CH_4.

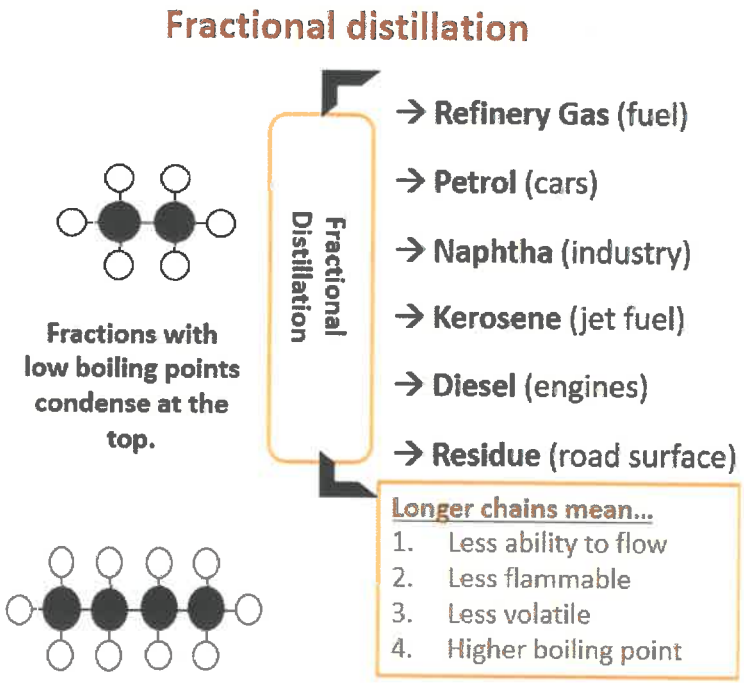
In chemistry carbon forms 4 bonds (represented by lines).
Hydrogen can form one bond.
Its **structure** is represented as:



09.4 CRUDE OIL AND FUELS.KO.2022-23

Fractional Distillation

Crude oil is separated using **fractional distillation**. The **hydrocarbons** within crude oil have **different chain lengths** which means they have different **boiling points.**



1. The **crude oil** is **heated** to 350°C. Most of the mixture **evaporates** into a gas.
2. The **gases** enter the bottom of the column (the hottest part)
3. The column has a **temperature gradient,** so it is cooler at the top. As the gases travel through the column they cool. Once they reach their **boiling point** they will **condense** back to a liquid and be collected.
5. The **longest chain** hydrocarbons with the **highest boiling points** are separated at the **bottom** of the column and the **shorter chain** hydrocarbons with **low boiling points** are separated at the top of the column.

Properties of Hydrocarbons

The **difference** in **chain length** affects the **properties** of the **hydrocarbons** and allows us to separate them. This also determines their usefulness for specific jobs.

Boiling point: increases with **longer chain lengths**. This is due to the **increased number** of **intermolecular forces** between molecules as the chain gets longer.

Viscosity: increases as you **increase chain length**. Long chain alkanes are very thick and gloopy- high viscosity. Short chain alkanes are runny (or gases!)- low viscosity. This also due to **intermolecular forces**.

Flammability: The hydrocarbons get **less flammable** with **longer chain lengths**. It is harder to set them on fire.

Volatility: Hydrocarbons become **less volatile** with **longer chain lengths**. They are less likely to turn into a gas.

Burning Hydrocarbon Fuels

Definition of complete combustion: occurs in presence of **excess oxygen** producing **water** and **carbon dioxide**.

Definition of incomplete combustion: occurs when there is a **lack of oxygen**. Instead of producing carbon dioxide the fuels produce **carbon monoxide** and/or **carbon**.

Examples of **different types of combustion** for methane:

$CH_4 + \mathbf{2O_2} \rightarrow \mathbf{CO_2} + 2H_2O$

$CH_4 + \mathbf{1.5O_2} \rightarrow \mathbf{CO} + 2H_2O$

$CH_4 + \mathbf{O_2} \rightarrow \mathbf{C} + 2H_2O$

Other Combustion Products

Some fuels contain **sulfur** which when burnt produces **sulfur dioxide**.

$S + O_2 \rightarrow \mathbf{SO_2}$

When fuels burn at **high temperatures inside car engines** then **nitrogen from the air** can react with **oxygen** to form **oxides of nitrogen**.

$N_2 + O_2 \rightarrow \mathbf{2NO}$

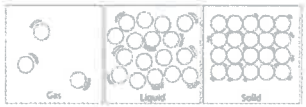
09.5 PARTICLES AND HEATING.KO.2022-23

States Of Matter

Solid
Particles **vibrate** around **fixed positions** but are held in place by reasonably **strong bonds**.

Liquid
Particles move about at **random** but still **remain touching** their nearest neighbour particles. There are **some**, **weak**, **forces** holding the particles close.

Gas
Particles move about at **random** at **high speed** and have **large gaps** between them and almost **no forces** of attraction.



Density

Definition of Density: density is the **mass per unit volume of a substance** (which means it it is a number that tells you how compact a material is for the space it takes up).

Units: g/cm³ or kg/m³.

Symbol: ρ (not a letter "p") spelled "rho" and pronounced "row as in 'I row the boat'".

Examples: lead is very dense and a small amount of it feels heavy (has a lot of mass). Oxygen is a gas and is the opposite: it is not very heavy even when there is a large volume of it).

Equation linking density, mass and volume

$$density = \frac{mass}{volume} \quad \rho = \frac{m}{V}$$

also $V = \frac{m}{\rho}$ **and** $m = \rho \times V$

The link between density and floating or sinking in water. Water has a density of 1g/cm³ or 1000 kg/m³. If any substance has a density greater than 1 it will sink; less than or equal to 1 means it will float.

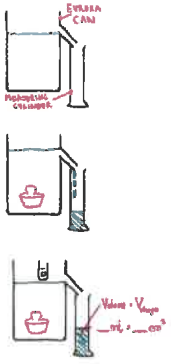
Measuring Density

Regular objects

1. Measure the length, width, height.
2. Multiply to get volume.
3. Measure mass with a balance.
4. Calculate density = mass ÷ volume".

Irregular objects

1. Measure the mass of the object with a balance.
2. Fill a eureka can with some water past its spout.
3. Let excess water run out.
4. Submerge the object under the water.
5. Measure all the water that comes out of the spout with a measuring cylinder.
6. This is the object's volume.
7. Calculate **density = mass ÷ Volume**



Heat Transfer

The direction of heat flow when two objects touch depends on **which one is hottest**.

The **object** at the **higher temperature** will **transfer heat** more **quickly** than the object at the lower temperature.

This is summarised (a little bit) simply as **heat moves from hotter objects to colder objects**. *There is a little more to it than this, but this is ok for GCSE.*

Objects and materials can be solid, liquid or gas and this controls how heat energy moves or is ***transferred***.

A common misconception ...

... about heat in everyday language might go something like this:

"Shut the window you'll let the cold in" ...

... and an appropriate response should be

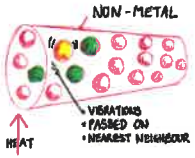
"Cold is an absence of heat energy. It is the hotter air leaving the room that you should be worried about".

Conduction

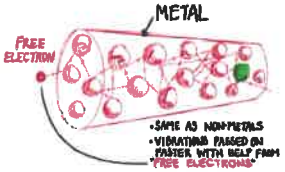
Definition of Conduction: Conduction is the movement of heat energy from a hotter region through a solid to a colder region.

Conduction theory:

Conduction in non-metals happens by **particles** simply **vibrating** and starting their **neighbouring particles** vibrating **because** they are touching.



Conduction in metals happens in two ways. The **first** way is just like non-metals. The **second** way is that **free electrons** in the metal move through the gaps in between particles to start other particles vibrating.



Good conductors are solids and the **best** conductors are **metals**.

09.5 PARTICLES AND HEATING.KO.2022-23

Changing State

Freezing (l→s)
The change of state from liquid to solid.

Melting (s→l)
The change of state from solid to liquid.

Evaporating (l→g)
The change of state from liquid to gas.

Condensing (g→l)
The change of state from gas to liquid.

Sublimation (s→g)
The change of state from solid to gas.

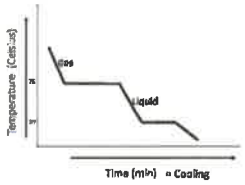
Deposition (g→s)
The change of state from gas to solid.

Boiling is **not the same** as **evaporation...** Evaporation is liquid-turning-to-gas at the ***surface*** of a liquid. Boiling is liquid-turning-to-gas ***inside*** the volume of the liquid.

Heating Curves

A "Heating Curve" or a "Cooling Curve" is a **temperature vs time** graph of a substance as it is heated (or cooled) and changes state.





Interpretation

They **give** you the **melting/freezing point** temperature or the **evaporation/boiling point** temperature.

The "freezing point temperature" and the "melting point temperature" are the same. One is called the melting point temperature if the substance is being heated and over time it will melt. The other is called the freezing point temperature if the substance is being cooled and it will solidify over time.

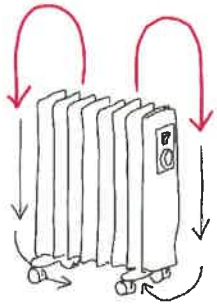
Convection

Convection occurs **only** in **liquids** and **gases**.

When you heat a region of a gas or liquid, the **particles move faster**. The space between individual particles increases. This causes the density of the region being heated to decrease.

Because liquids and gases can flow, the **warmer** and less dense region will **rise** above denser, cooler regions.

Convection Currents.



The metal radiator gets hot from hot water passing through it.

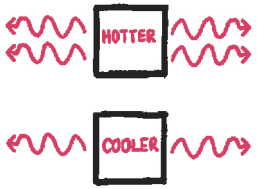
The metal touches the air around it and heats it (conduction).

The **hotter air rises** and is **replaced** by **cooler air**, which gets heated and rises, which is replaced by cooler water and so on.

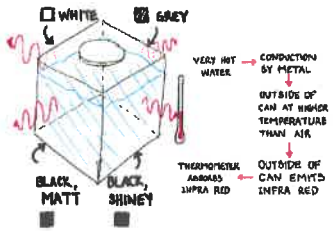
Radiation IR Emission

Definition of emit / emission: emit means to give off or give out a gas or radiation.

Definition of radiation: the emission of energy as electromagnetic waves.



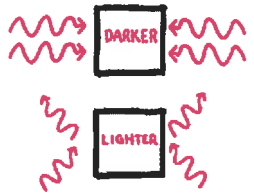
Definition of infra-red radiation: like red coloured light, infra-red is an electromagnetic wave. It has a wavelength too long to be seen by the human eye. It is a type of light given off by all (hot) objects.



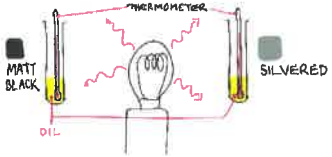
Radiation IR Absorption

Definition of absorb/absorption: all objects will absorb ("take in") some infra-red light. The more they absorb, the more their temperature increases.

If an object absorbs **more** infra - red light, then it emits its temperature will **in**crease.



If an object absorbs **less** infra -red light, then it emits its temperature will **de**crease.



09.5 PARTICLES AND HEATING.KO.2022-23

Insulators

Definition: Insulators ...

... are materials that are not so good at conducting. They behave the opposite to conductors.

Common uses of conductors

Common uses of insulators

Definition: Thermal conductivity is a number which tells you how good a material is at conducting heat energy through it. The higher it is the better it is at conducting.

Metals conduct **best** and have the **highest** thermal conductivity number.

Non-Metals conduct next best and have **high** thermal conductivity numbers.

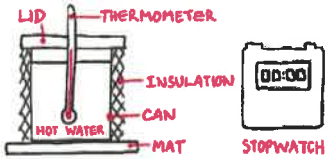
Liquids and **gases** conduct very **badly** and have the **lowest** thermal conductivity numbers.

Insulation Practical

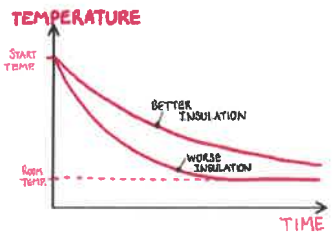
The amount of heat energy transfer through a layer of material depends on

1. The **temperature difference** across the material.
2. The **thickness** of the material.
3. The **thermal conductivity** of the material.

Diagram:



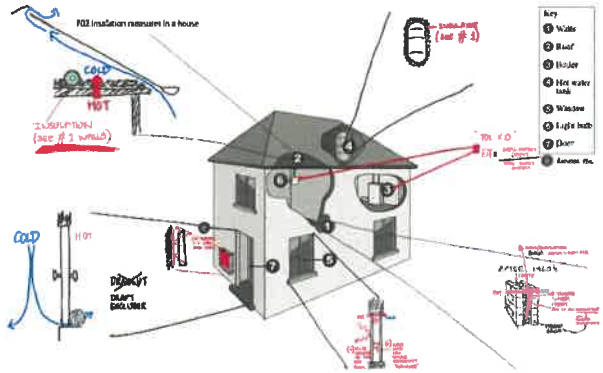
Expected results:



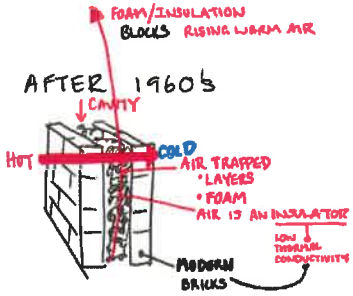
Interpretation:

Better insulators keep the heat energy in the water for longer so the curve is less steep.

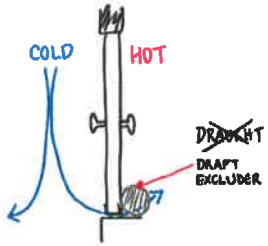
Methods of reducing heat loss from houses



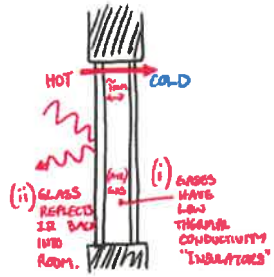
Cavity wall insulation



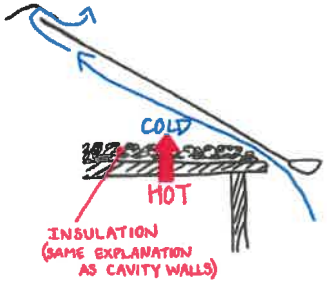
Draft Excluders



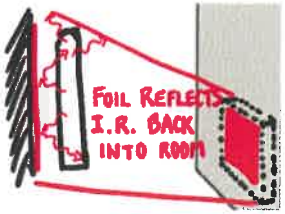
Double Glazing air (vacuum) gaps



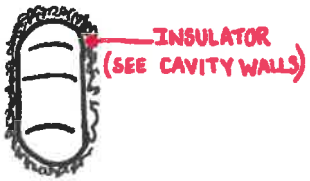
Loft Insulation



Foil-behind-radiators



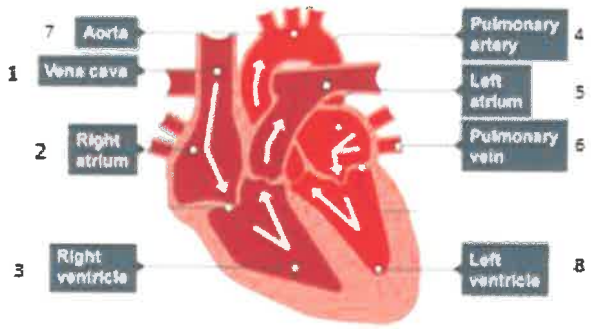
Boiler Insulation



09.6 TRANSPORT IN ANIMALS AND PLANTS.KO.2022-23

Heart Structure

Order of numbers is the **way in which blood flows** through the heart



Heart: A biological pump. Four chambers: two atria, two ventricles. Made of (cardiac) muscle

Right atrium: Receives **deoxygenated blood** from the body through the **Vena cava vein.**

Left atrium: Receives **oxygenated blood** from the lungs through the **Pulmonary vein**.

Pacemaker: Group of cells in the **right atrium** that controls **resting heart rate.**

Right ventricle: Pumps **deoxygenated blood** to the **lungs** for **gas exchange**. Thinner muscle.

Left ventricle: Pumps **oxygenated blood** to the **body**. **Thick, muscular** wall.

Valve: Stops blood flowing the **wrong way** / backwards.

Blood: 4 parts

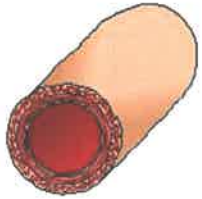
Plasma: **Liquid** part of the blood. Transports blood cells as well as **carbon dioxide, proteins, glucose, hormones** and **urea.**
Red Blood Cells: **Carries oxygen.** Packed with **haemoglobin,** a protein that binds to oxygen. **No nucleus** to create extra space for haemoglobin. **Biconcave shape** to give a **large surface area.**
White Blood Cells: **Destroy pathogens.** Some can produce **antibodies.**
Platelets: Cell fragments that help to **clot wounds.**

Artery



Function: Takes blood away from the heart.
Structure: Thick (muscle & elastic) wall to withstand high pressure.
Narrow hole (**lumen**) to maintain high blood pressure (so blood moves quickly over large distances in the body).

Vein



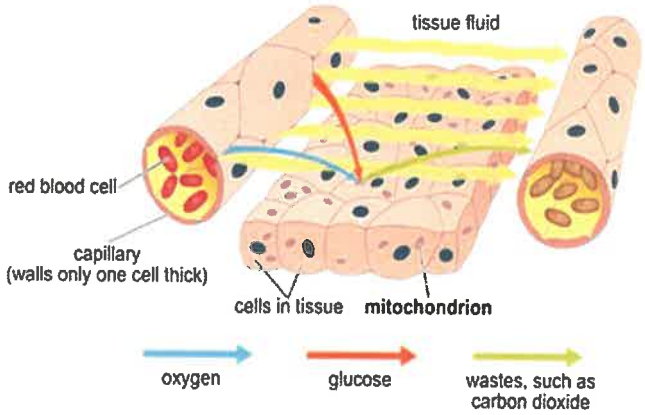
Function: Takes blood into the heart.
Structure: Thinner (less elastic & muscle) wall because blood pressure is low.
Widest hole (**lumen**) – low pressure blood, less resistance.
Valves stop blood flowing backwards.

Capillary



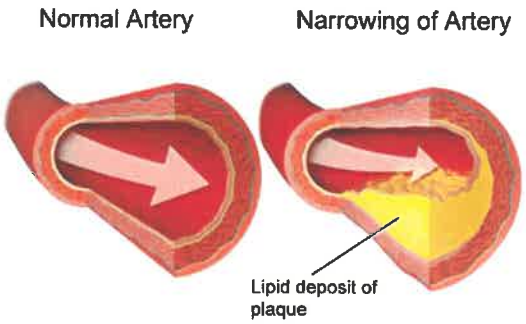
Function: Exchange of substances between cells (tissue fluid around cells) and blood.

Structure: Wall is very thin –only one cell thick. To allow quick diffusion of substances (e.g. waste carbon dioxide diffuses into blood and nutrients diffuse out of blood into cells.)



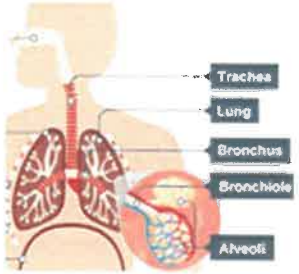
Coronary Heart Disease

Build-up of fatty material in coronary arteries. Can lead to a blood clot and a heart attack.



Treatment	What it is	Advantage	Disadvantage
Stent	**Wire mesh** that **opens up** a **blocked artery.**	Keeps artery open. Low-risk surgery.	Fatty material can rebuild.
Statin	Drug that **reduces cholesterol.**	Reduces fat being deposited in arteries.	Side effects e.g. liver damage.
Heart transplant	**Replacement heart** from a donor.	Long-term.	Major surgery. Could be rejected.
Artificial heart	**Man-made heart** used while **waiting for a transplant.**	Not rejected. Keeps patient alive.	Short lifetime. Battery has to be transported. Limited activity.
Mechanical heart valve	Mechanical replacement of faulty heart valve.	Can last a lifetime.	Can damage red blood cells.
Biological heart valve	Biological replacement of faulty heart valve.	Don't damage red blood cells.	Valve hardens and may need replacing.

Lungs



Alveoli:

Small sacs where gas exchange occurs. Surrounded by capillaries. Oxygen moves from the alveoli into the capillaries, carbon dioxide moves from the capillaries into the alveoli.

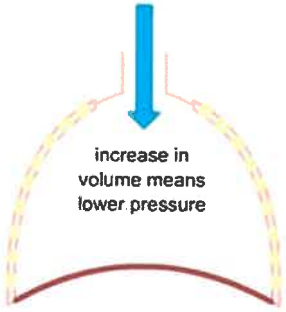
Trachea, **bronchus** & **bronchioles**:

Tubes through which gases move. Lined with cartilage so they don't collapse.

Gas Exchange in the Lungs

Diaphragm & intercostal muscles **contract.**

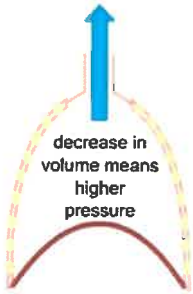
breathing in



ribs move up and out
diaphragm flattens
volume of chest increases

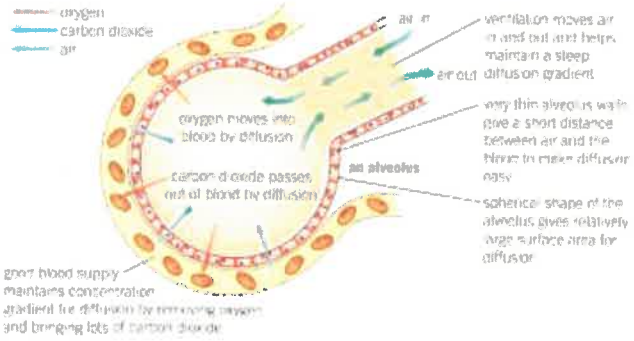
Diaphragm and intercostal muscles **relax.**

breathing out



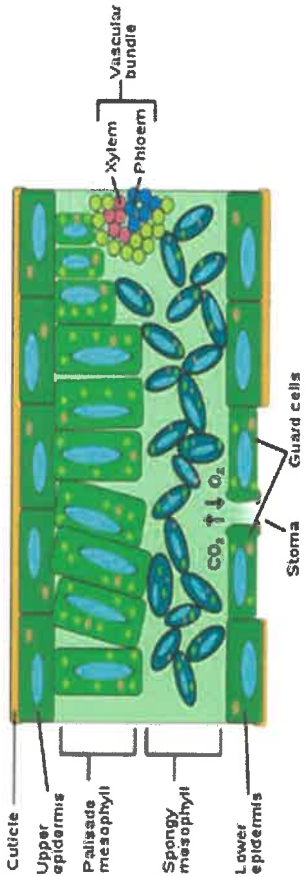
ribs fall
diaphragm moves up
volume of chest decreases





09.6 TRANSPORT IN ANIMALS AND PLANTS.KO.2022-23

Leaf Structure



Plant Cell and Tissue Adaptations

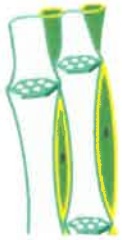
Root hair cell
Extension gives a large surface area to absorb water and minerals.



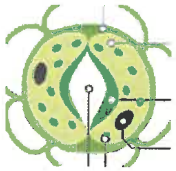
Xylem
Vessels are strengthened by lignin to withstand pressure. Cell walls are waterproof.



Phloem
End of cells contain pores to allow dissolved sugars to move between cells.



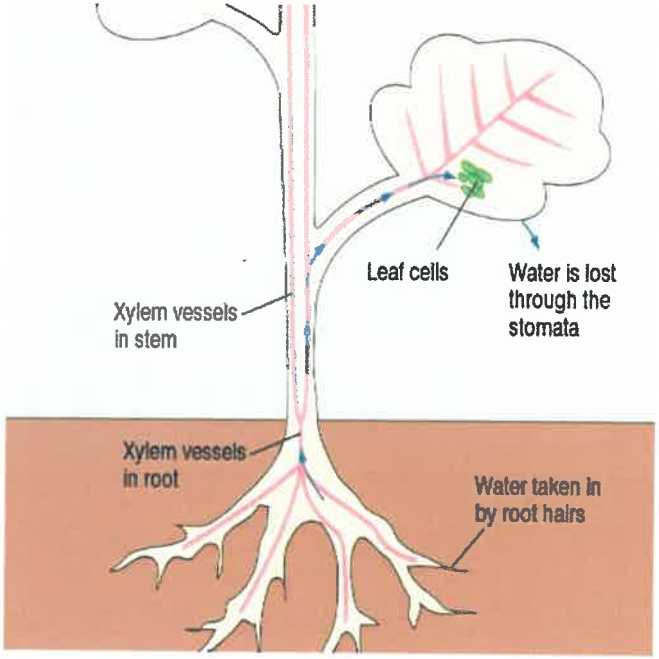
Guard Cells and Stoma
Guard cells can open the stoma to allow gas exchange or close to prevent water loss.



Epidermis	Cover the surfaces of the leaf; lets light penetrate.
Xylem	Carries water and minerals from the roots around the plant.
Phloem	Carries dissolved sugars made through photosynthesis around the plant. 6
Palisade mesophyll	Where most photosynthesis takes place. Cells contain many chloroplasts. Absorbs light.
Spongy mesophyll	Some photosynthesis. Has air spaces for diffusion of CO_2 and O_2.
Guard cells	Cells that open and close stomata.
Stoma	Opening that allows CO_2 and O_2 to diffuse in and out of the leaf.

Plant Transportation

Transpiration: The loss of water vapour from the leaves by **evaporation** from cells and then out through the **stomata**.
Transpiration stream: The **movement of water** from the **roots, up** the **xylem** to the **leaves. One way** only. Only water and minerals involved.
Turgid: A cell that has taken in water by osmosis and swelled
Flaccid: A cell that has lost water by osmosis and shrunk.
Wilted: A plant that has lost water faster than it absorbs water from the soil. The plant collapses. Can cause permanent damage.

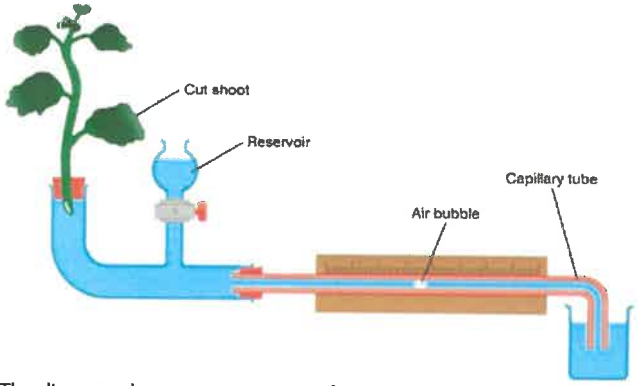


Factors Affecting Transpiration Rate

Temperature	Increasing temperature increases the transpiration rate as water evaporates quickly.
Humidity	Increasing humidity decreases the rate of transpiration as water evaporates slowly.
Wind speed	Increasing wind speed increases the transpiration rate as water evaporates quickly.
Light	Increasing light increases the rate of transpiration as stomata open.

Transpiration at its highest on dry, hot, sunny days (same conditions that help clothes dry)

Potometers measure transpiration



The diagram shows a comparison of transpiration (in the xylem) with translocation (in the phloem).

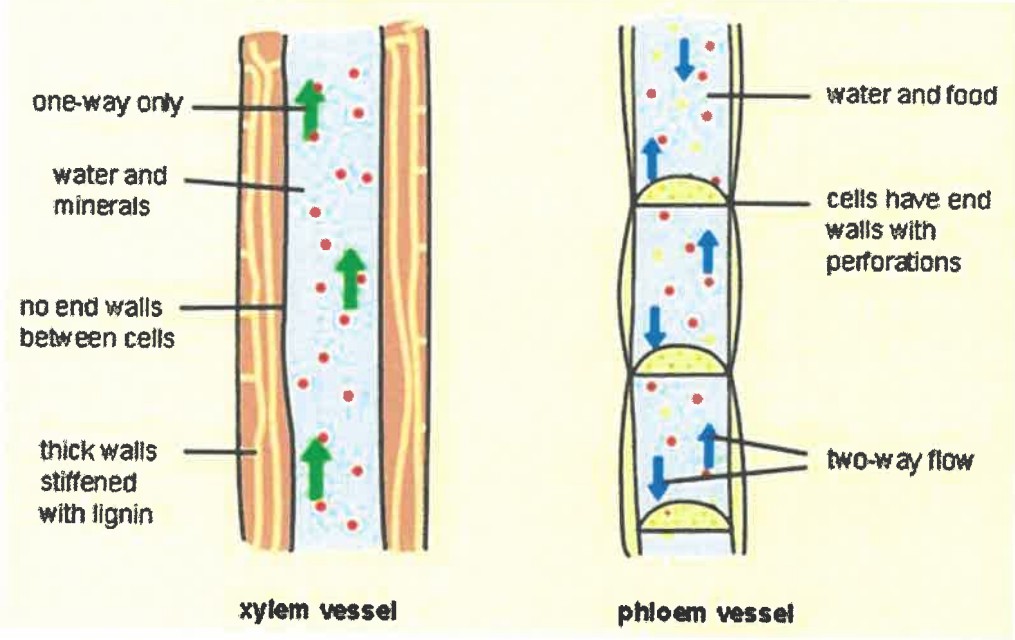
A potometer can be used to measure the rate of transpiration. As the leaf loses water, so the air bubble moves.
The distance moved over a time period is measured (mm/min).
This is the rate of transpiration.

Translocation

Happens in the phloem only.

The **movement** of **dissolved sugars** around the plant. **All directions** (up, down, sideways).

From **source** (e.g. leaf – where sugars are made) to **sink** (e.g. fruit for storage).



09.7 MICROBES.KO.2022-23.2022-23

Health and disease

Key words

Micro-organism- organism that is so small you need a microscope to see it

Pathogen.A disease causing microbe

Virus.the very smallest microbe, causes disease

Fungi. Made of many cells, like mushrooms or one cell, like yeast - can cause disease

Bacteria. Single celled microbes. bigger than viruses, they can cause disease

Disease. An illness or symptoms caused by a microbe

White blood cells. Destroy microbes that cause disease

Antibodies. White blood cells make these to protect you from disease

Vaccine. Can make you immune to a disease

Pathogens and disease

What is a pathogen?

A pathogen is a microorganism which causes disease, common pathogens are bacteria and viruses. There are 4 types you need to know. Bacteria, Viruses, Protists and Fungi.

A communicable disease, also known as an infectious disease, is spread by a pathogen



Bacteria

What are 6 common symptoms of disease?

1.High temperature, 2.Fever, 3.Vomiting, 4.Diarrhoea, 5. Headache, 6.Rash

How are pathogens spread?

Direct contact can be through a cut in the skin or sexually transmitted through bodily fluids.E.g.HIV/AIDS.
Plants can also be affected in a field if one plant gets infected the other plants touching it will be infected as well E.g. Tobacco mosaic virus
Bacteria, viruses and fungi are transferred in food and water.



How are pathogens spread?

Bacteria, viruses and fungi are transferred when an infected person touches a healthy person

.

Mosquitos carry the pathogen Plasmodium. This is the parasite that causes Malaria when bitten by the mosquito. The mosquito is called a vector.



Droplets from your breathing system are released, these contain pathogens.



Someone breathes in the droplets and the pathogen so they get infections

In direct contact is a result of touching surfaces or areas where pathogens been from someone else e.g. athletes foot

Bacteria, viruses and fungi are carried in the air from one organism to another

Bacteria, viruses and fungi are transferred when an infected person touches a healthy person.

Preventing infections

Ignaz Semmelweiss



Informed pathogens can spread from one person to another. He saw a doctor die after cutting himself from the same fever that the mothers were dying from. He told them to wash their hands in chlorinated water before delivering babies and fewer women died.

Joseph Lister



Joseph Lister developed the idea of antiseptics. These solutions kill microbes. He was a surgeon and used carbolic acid to sterilise his instruments. Antiseptics can be used on surfaces and our skin. They greatly reduce numbers of infection.

Louis Pasteur

Understood that microorganisms are in the air

Alexander Fleming



Alexander Fleming discovered that a mould called penicillin produced a chemical that would kill bacteria. The fungus grew on one of his agar plates and caused an area where bacteria could not grow. This was the first Antibiotic

Preventing the spread of disease

Hygiene

Using Disinfectants in the house

Keeping raw meat away from cooked meat

Coughing or sneezing into a tissue or into your hands

Maintaining hygiene for people using agricultural machinery to help prevent the spread of plant disease

Isolation

Isolation of people with serious infectious disease. Fewer people who come into contact, reduces the spread Same for plants – only small plants can be destroyed or moved.

Destroying vectors

Killing mosquitos and preventing them from breeding. Pest control e.g Rats and Aphids.

Giving vaccinations

Give patients small amounts of dead or weakened specific pathogens, that means that when the patient comes into contact with the real disease the body can fight it quickly.

09.7 MICROBES.KO.2022-23.2022-23

Viral disease

Viruses are not alive because they do not complete all
of the seven life processes:
Movement, Respiration, Sensitivity, Nutrition, Excretion, Reproduction and Growth.
We say 'strains' of virus and not species. They are made of a relatively short length of genetic material DNA which is surrounded by a protein coat.
The life cycle of a virus is the same as other pathogens. They can often survive outside a host for long periods of time. When they have infected a suitable host cell or cells, they replicate themselves within the cell thousands of times. They do not divide and reproduce, but replicate their DNA and protein coats. These are then assembled into new virus particles. The host cell or cells then burst and other nearby cells can be infected with the virus. This process can be as quick as twelve hours in the case of the Norovirus or several days for Ebola.
Viral infections cannot be treated by antibiotics



Diagram of a virus showing a protein coat that surrounds its genetic material.

Viral diseases in humans

Measles

Measles is a very infectious viral disease that is often caught by young children. It is transmitted through the air in tiny droplets after an infected person sneezes. It causes a fever and skin rash. Many children in developed countries are given vaccines against measles, but sadly this is not the case throughout the world. Infection can cause more serious effects like infertility in adults who did not catch the disease as children.

Main symptoms of measles include:

Cough, fever, red eyes, light sensitivity, muscle aches, runny nose, sore throat, white spots inside the mouth.



HIV/AIDS

HIV stands for human immunodeficiency virus. This infection is transmitted by body fluids, often during unprotected sex, cuts and using shared needles. Immediately after infection, people often suffer mild flu-like symptoms. These pass and for a period of time infected people might not know they are infected.

AIDS stands for acquired immune deficiency syndrome. Months or years after the infection of the HIV virus, it becomes active and starts to attack the patient's immune system. HIV at this point has become AIDS.There is no cure for HIV /AIDS although many scientists are trying to find one. Currently, infected people are given antiviral drugs, which can slow the development of AIDS.

Viral disease in plants

Tobacco mosaic virus
The tobacco mosaic virus infects tobacco and lots of other closely related species, such as tomatoes and peppers. It is transmitted by contact between plants, either naturally or through the hands of farmers. It infects the chloroplasts of plant leaves and changes their colour from green to yellow or white in a mosaic pattern. It can also make leaves crinkle or curl up.
This reduces the plant's ability
to photosynthesise and grow properly, which reduces the crop yield for farmers.
There is no cure therefore farmers must try to reduce the infection to their crops or attempt to reduce the spread of the virus.



Tobacco mosaic virus infects chloroplasts in the leaves of plants

Bacterial diseases In humans

Salmonella food poisoning

Salmonella is a type of bacteria that lives in the guts of many animals. This is why the bacteria is often found on raw meat, eggs, poultry and some egg products such as mayonnaise. If these bacteria get into the gut of our bodies it can cause Salmonella food poisoning. One common cause of this infection is eating undercooked food or by preparing foods in unhygienic conditions.

The symptoms develop within 72 hours of eating the infected food. Symptoms include vomiting, diarrhoea and cramps. The symptoms don't last long, usually only a few days, so antibiotics are often not administered. In countries where malnutrition is a problem Salmonella can be a lot more dangerous.

In the UK, poultry are vaccinated against Salmonella to control the spread of disease. To prevent food poisoning keep raw chicken away from uncooked food, wash hands and surfaces well after handling raw chicken and cook the chicken through thoroughly.

Salmonella bacteria





Gonorrhoea

This is a sexually transmitted disease, which can also be known as a sexually transmitted infection. The bacteria is able to spread from person to person during unprotected sex.

The symptoms of gonorrhoea are apparent early on, but if left untreated the symptoms will disappear even though the infection persists within the body. The early symptoms include a thick yellow or green discharge from the vagina or penis and pain on urination. However, some men and women do not get any symptoms at all. If left untreated it can cause long-term pelvic pain, infertility and ectopic pregnancies.

Gonorrhoea can be treated with antibiotics, originally penicillin cured the infection recent strains of the bacterium make it increasingly difficult to treat. All sexual partners must be treated with antibiotics to prevent the spread of the disease within a community. The spread can also be prevented by using condoms.



Bacterial disease in plants

There are relatively few bacterial diseases of plants and these diseases are usually found in tropical and sub-tropical regions. *Agrobacterium turnefaciens* is a bacterium that causes crown galls to grow between the root and the shoot of an infected plant. The bacteria inserts plasmids into the plant cells, this genetically modifies the cells and causes a mass of cells to grow



Crown galls growing between roots and shoots of a plant.

Fungal and protist diseases

There are 3 diseases to learn

Name of disease	Protist or fungus	How to prevent harm to the host.	Symptoms	How the disease affects the organism.
Rose Black Spot	Fungus	Removing the affected leaves, fungicides.	Purple or black spots, leaves turn yellow and drop early.	Reduces photosynthesis if the number of leaves decreases.
Malaria	Protist - plasmodium	Preventing mosquitos from breeding (removing stagnant water), mosquito nets, repellants and avoid being bitten, medications.	Recurrent episodes of fever, sweats and chills, headaches, vomiting, diarrhoea and can be fatal.	Plasmodium protist enters the liver cells where it multiplies and released into blood. Plasmodium destroys red blood cells.
Athlete's foot (tinea pedis)	Fungus	Good feet hygiene, do not share items for the feet, do not walk around public areas barefoot.	Itchy, red, scaly, dry, cracked or blistered skin.	Fungi called dermatophytes feed off dead skin and keratin and multiply, causing damage to the organisms' cells.

Athletes foot

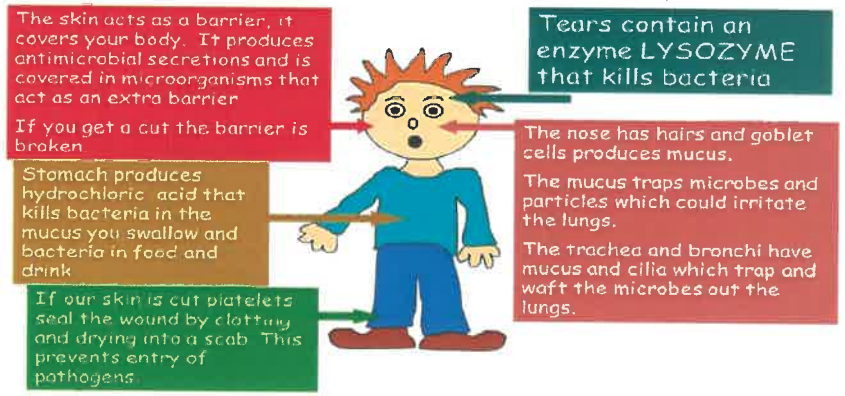




Rose black spot

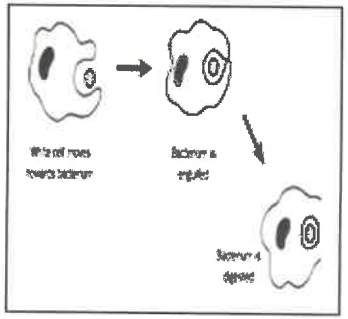
Human defences

Our bodies have many defence mechanisms against invading pathogens (micro organisms that can cause disease):



White blood cells act in **3** ways to **defend** the body:

1. White blood cells (called **phagocytes**) engulf the pathogens and digest them. This is called **phagocytosis**.
2. White blood cells (called **lymphocytes**) identify the **antigen** on the pathogen. They make **specific antibodies** to destroy the pathogens. This can take time and so an infection may occur. If a person is **infected again** by the same pathogen, the white blood cells make the **antibodies** much **faster.**



3.Bacteria may produce toxin (poison). White blood cells release specific **antitoxins** to **neutralise** the effect of the toxin.



09.8 ELECTROMAGNETIC WAVES.KO.2022-23

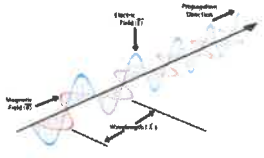
EM Waves

Definition: Electromagnetic waves ("EM waves") are transverse waves that transfer energy through space without any need for a material.

Fact: They two waves. The first wave is an electric wave. The second wave is a magnetic wave.

Fact: They happen at the same time and travel together.

Fact: One causes the other, the other causes the one.



Speed of Light, c

All EM waves travel at the speed of light has the symbol "c". $c = 3 \times 10^8 m/s$. The speed of light is the same everywhere.

Wave equation

$$c = f \times \lambda$$

When the wavelength of EM waves gets longer (i.e. a bigger number) the frequency gets smaller.

(Non)-Ionising

Definition: Non-ionizing radiation...

EM waves **do not have enough energy** to separate electrons from atoms or molecules, so they don't ionise them, or break chemical bonds that could causing chemical reactions or DNA damage.

Definition: Ionizing radiation...

EM waves **have enough energy** to separate electrons from atoms or molecules, ionising them, or to break chemical bonds, causing chemical reactions or DNA damage.



Spectrum

Definition: A spectrum is band of colours (think "rainbow") but the word is also used to describe the entire range of wavelengths of electromagnetic radiation.

Radio waves

Background info

Radio waves were predicted by James Clerk Maxwell in 1867. They were discovered by Heinrich Hertz in 1887. The unit of frequency is named after Heinrich Hertz.

Typical Wavelength λ

$1000m$ *or* 10^3m down to 1m

Wavelength-sized everyday object

Buildings, hills, humans

Sources

Stars like our sun; radio transmitters; microwave ovens; mobile phones

Non-ionising

Penetrate Earth's Atmosphere

Mostly yes.

Dangers

None

Applications

TV signals; radio signals

Microwaves

Background info

Microwaves are not-ionising but cause water and fat molecules to vibrate more so that they can be used to heat up materials that have fat and/or water in them; like food. The first (domestic) microwave oven was sold in 1967.

Typical Wavelength λ

$0.01m$ *or* $1cm$ *or* 10^{-2}m

Wavelength-sized everyday object

Honeybee; thumbs.

Sources

Stars like our sun; radio transmitters

Non-ionising

Penetrate Earth's Atmosphere

Mostly yes.

Dangers

Can cause molecules to vibrate a lot ('heating') so they can damage tissues/skin.

Applications

Satellite and TV signals; mobile phone communications

Infra-Red

Background info

Discovered in 1800 by William Herschel. The longest EM waves humans can see are red waves. Infra means "below" (Latin) because infrared have wavelengths 'below' red light when the spectrum is ordered.

Typical Wavelength λ

$0.00001m$ *or* 10^{-5}m

Wavelength-sized everyday object

Amoeba.

Sources

Stars; **all** hot objects

Non-ionising

Penetrate Earth's Atmosphere

Mostly Yes

Dangers

Can cause molecules to vibrate a lot ('heating'); can damage cells.

Applications

Infra-red "night sight" cameras; healing sports injuries; astronomical measurements; weather forecasts; remote controls signals.

Cooking (grills, toasters, BBQs)

09.8 ELECTROMAGNETIC WAVES.KO.2022-23

Visible light

Background info

Your retina has two types of cells for light: colour ("cone" cells) and brightness ("rod" cells). They can only detect a small part of the EM spectrum. We call that part visible light.

Typical Wavelength λ

Violet: $3.8 \times 10^{-7} m$
Blue: $4.5 \times 10^{-7} m$
Green: $5 \times 10^{-7} m$
Orange: $6 \times 10^{-7} m$
Red: $7 \times 10^{-7} m$

Wavelength-sized everyday object

Cells

Sources

Stars; flames; lamps

Non-ionising

Penetrate Earth's Atmosphere

Yes

Dangers

No. Only very bright light can damage your retina cells: don't stare at the Sun.

Applications

'Seeing'; communication; fibre optics.

Ultraviolet

Background info

"Ultraviolet" means "beyond violet" (Latin *ultra* = "beyond"). Discovered by Johann Wilhelm Ritter in 1801 when invisible waves were noticed that were shorter than the violet light.

Typical Wavelength λ

$0.00000001m$ *or* 10^{-8}m

Wavelength-sized everyday object

Molecules.

Sources

UV lamps; Stars like our sun.

Ionising

Yes.

Penetrate Earth's Atmosphere

No.

Dangers

Sunburn; skin cancers; cataracts (over time UV turns the clear skin over your eye – the cornea – cloudy. It has to be removed by surgery).

Applications

Detecting forged bank notes; (sun) tanning; arc welding.

X-rays

Background info

Discovered 1895 by Wilhelm Röntgen. The world's first ever X-ray was his wife's hand.

Typical Wavelength λ

$0.0000000001m$ *or* 10^{-10}m

Wavelength-sized everyday object

Atoms.

Sources

X-ray machines; stars like our Sun.

Ionising

Yes.

Penetrate Earth's Atmosphere

No.

Dangers

Highly ionising and can cause cell mutations and cancer.

Although dangerous, there is no legal limit to the number of X-rays for patients: if your Doctor thinks you need it, you probably do...

Applications

Medical imaging; airport security.

Gamma rays γ

Background info

Paul Villard, a French chemist and physicist, discovered gamma radiation in 1900, while studying radiation emitted from radium.

Typical Wavelength λ

$0.000000000001m$ *or* 10^{-12}m

Wavelength-sized everyday object

Nucleus of atoms.

Sources

Radioactive isotopes; stars like our Sun.

Ionising

Yes.

Penetrate Earth's Atmosphere

No.

Dangers

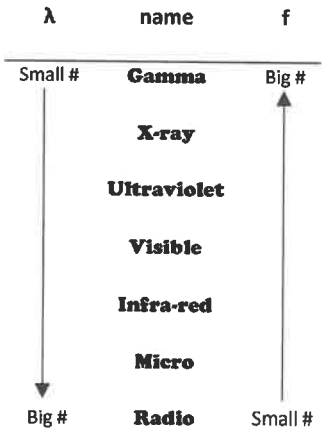
Highly ionising and can cause cell mutations and cancer.

Applications

Medical imaging using 'tracers'; killing cancer cells; sterilising medical equipment already in sealed bags; killing microbes.

Must knows

Order the spectrum in order of increasing wavelength



09.9 ENVIRONMENTAL SCIENCE.KO.2022-23

• Effects of Pollution on Atmosphere

Climate Change is caused by:

1. **Carbon dioxide** is produced by **burning fossil fuels**, production of **concrete** and **deforestation**.

2. **Methane** is produced from **farming particularly cows, landfills**, **rice** production and **fossil fuel production**.

Many scientists believe that **human activities** will cause the temperature of the Earth's atmosphere to increase resulting in **global climate change**. The **data** is based on very **complicated models** and as such **simplified data** is often used in the media which can be **biased**.
Scientific research in journals is **peer reviewed** which helps to **reduce bias**. The consequences of **global warming will affect billions** of people all around the world particularly those who live on **smaller islands or coastal communities.**

Climate change can lead to the following:

- **Glaciers** and **polar ice melting**
- **Sea-level rising**
- **Patterns of rainfall changing** (more floods or droughts)
- **Habitats changing**
- **Animals migrate towards poles** to find habitats with suitable temperatures
- **Tropical diseases** may become **more common** in other regions such as Europe.
- **Species** will become **extinct**

Other Atmospheric Pollutants
Carbon monoxide – toxic, colourless and odourless so difficult to detect

Sulfur dioxide and oxides of nitrogen – acid rain, increase in asthma and other respiratory problems

Particulates (carbon/unburnt hydrocarbons) – lung damage depending on side of particulates, **global dimming**, reduces photosynthesis, smog.

• Land and Water Pollutants

Fertilisers:
When they enter **lakes** or **rivers,** they can cause **eutrophication**.
Algae grows rapidly
Blocks out **light** and **reduces oxygen**
Plants die
Bacteria aerobically respire while decomposing the plants
Oxygen levels drop
Organisms die

Pesticides/herbicides:
When they enter rivers/lakes they **kill insects or plants** in the area. In small amounts they can **build up in the food chain** and affect other animals which feed on those in the lake/rivers such as otters/herons etc

Landfill:
Humans bury **household waste** in landfill sites. Over time these can **leak hazardous chemicals** into the soil and water which can affect the organisms which live there

Nuclear waste:
Usually **buried underground** but explosions and nuclear accidents can spread toxic radioactive waste over a large area as the radioactive particles are carried by the wind.

Acid Rain:
Damages buildings, **destroys forest** habitats by removing minerals from the soil, **destroys lake habitats** as the lake becomes acidic reducing amount of oxygen which can dissolve in the lake.

• Pollution Indicators

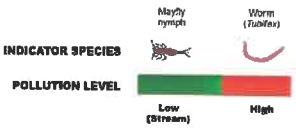
Definition of bioindicators: organisms whose presence can determine the level of pollution in an area.

Lichen: can be an indicator of air pollution as **sensitive to sulfur dioxide**. Bushier lichen means there is less sulfur dioxide/acid rain in that area. Leafy lichen can survive in small amounts of pollution and crusty lichen in more polluted air.





Aquatic Invertebrates:
presence of certain invertebrates in streams and rivers can indicate how polluted the water is**.**
Mayfly larvae/caddis fly larvae/ stonefly larvae are only found in **unpolluted areas** and **sludge worms/ bloodworms** are found in areas of **high pollution**



• Biodiversity

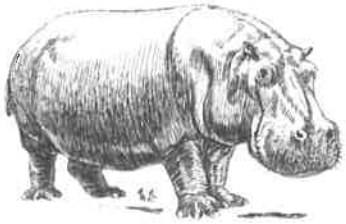
Definition of Biodiversity: The variety of all the different species of organisms on earth, or within an ecosystem.

Some habitats have greater biodiversity than others for example the **rainforests** and the **coral reefs** have **higher biodiversity** than the arctic circle.

The higher the biodiversity the better as each species will be less reliant on only one other food source so the ecosystem is more stable as they can adjust to changes.

Human Activities can **negatively affect biodiversity**:

Habitat destruction
Invading species
Population increase
Pollution
Overexploitation



Habitat Destruction
Use **land** for **farms, housing** or to get **resources** such as timber/coal/metals

Invading species
Release of **non-native animals** which compete with the native organisms eg grey squirrels compete with native red squirrels in the UK

Population increase
In the past 100 years the words populations had gone from around 1 billion to 7 billion. This is due to better **healthcare**, new medicines, greater **food production**. **Increase demand** for **land, resources, pollution**, and **waste.**

Pollution
Rubbish on land and in sea gets mistaken for food. **Chemicals** released into water and air

Overexploitation: **hunting** (used to be wolves and beaver in UK but hunted to extinction), **overfishing**

• Deforestation

Trees are **cut down** (felled) to **clear land** for farming. No trees are planted to replace those that are cut down. This has been done on a small scale for thousands of years but now we clear much larger areas.

Reasons for deforestation:

- **Space for crops** such as rice, bananas, cocoa
- To **grow cheap ingredients** such as palm oil
- To **rear cattle**
- To **grow crops** like maize and sugarcane for **biofuels.**

Why are rainforests important?

- **Loss of habitats** for some animals which only live in rainforests
- Trees **remove CO_2** and **give out O_2**
- Important for **local economy**
- Most of the world's **biodiversity** exists in rainforests

Peat Bogs
Bogs are **wet areas of land** where moss grows. The water and acidic nature mean decomposition is slow and **peat** is formed from **partially decayed plants**.

Peat can be used as a **compost** or **burnt as fuel**. This reduces biodiversity. It is also classed as a **non-renewable fuel** which releases CO2 when it is burnt. Peat also acts as a **carbon store.**

• Maintaining Biodiversity

Definition of Conservation: the preservation of ecosystems and everything that lives within them.

Scientists and others **help maintain biodiversity** by:

- **Breeding programmes** to preserve endangered species
- **Protection** and **development** of new **endangered habitats**
- **Replanting hedgerows**
- **Reducing deforestation**
- **Reduce pollution**
- **Recycle** rather than dump waste in landfill sites

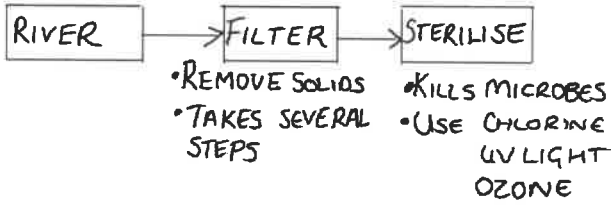
Why Maintain Biodiversity?

Prevent **extinction**
Rainforests contain **species** yet to be **identified by scientists**
Organisms living in these areas may provide **medicines**
Produce O_2 and **absorb CO_2**

• Water Treatment

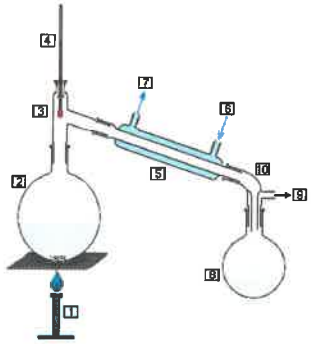
Definition of Potable water: **safe** to drink has **low level** of **dissolved minerals** and **micro-organisms** in it.

In the **UK** we have access to lots of **fresh ground water** which can be **treated** and used as **drinking water**.



Chlorine is **toxic** so is added in small amounts which **kills micro-organisms** but not those drinking the water. In some area's minerals will be added like fluoride ions. This reduces dental problems. Some people object to this as they are being made to drink something they may not want.

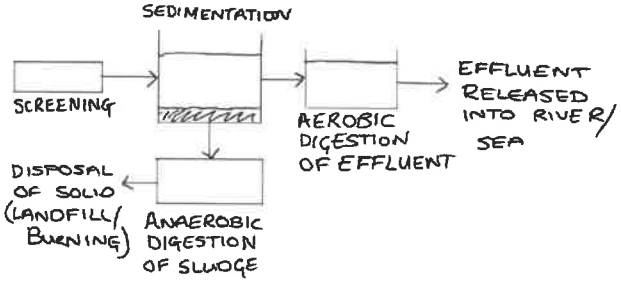
In countries with **limited fresh water** then **seawater** can be used.
Definition of desalination: process to remove salt from salt water.
Desalination can be done in 2 ways:
Desalination – a membrane is used, and the water is recovered using **reverse osmosis**. The membranes are **expensive**
Distillation – this gives pure water. The **seawater** is **heated** until it **boils at 100°C** and the **water vapour** leaves the reaction vessel and is cooled until it **condenses** back into a liquid **giving pure water**. This is also **expensive** due to the **high energy costs** involved.



• Waste Management

Wastewater comes from homes and businesses in the form of **sewage, agricultural waste** from farms and **industrial waste** from various industrial processes. The water needs **treating** before it can be **returned** to **rivers or reservoirs** as it will **contain microbes** which may be **dangerous** to human health and the ecosystem, **toxic chemicals and particulates** which would affect water quality.

Sewage treatment in the UK involves several steps:



Screening – remove solids
Sedimentation - allows small particulates to settle out of liquid.
Aerobic Digestion – occurs in oxygen, digest organic matter and harmful microorganisms
Anaerobic Digestion – no oxygen, temp 35-55°C

The effluent can be kept and further treated to make it potable water, but this is more expensive than using fresh water due to the processes involved.

Waste
People produce huge amounts of household waste which takes up room in landfill, destroys habitats and toxic chemicals leak into the surrounding soil.

• Reduce, Reuse and Recycle

Some natural resources are **finite** so we need to find ways to **reduce** and **reuse,** so they **do not run out**.

We can do this in 3 ways:
Reduce Use: thinner pieces of plastic, charges for use, less packaging etc
Negatives: flimsy materials and packaging

Reuse: use the item again (bottles, bags etc), find a new use for the item (use glass bottles to form part of a wall), or sell on the item to someone else
Negatives: some plastics can leach **toxic chemicals** into water/food

Recycle: the item is returned to its raw state (usually by **melting**) and **reshaped** into the same (aluminium cans) or a different product (plastic milk bottles become fleeces)
Negatives: some materials are not as strong after recycling, materials must be collected, sorted and stored which takes time and energy

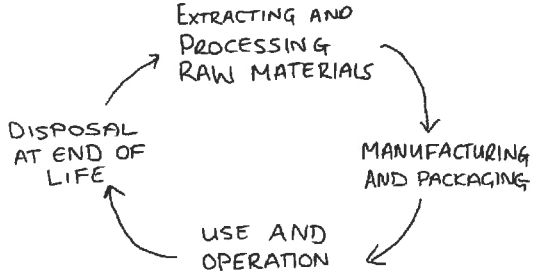
Positives:
Reducing the demand for new **raw material** which must be extracted. This reduces the impact of processes like quarrying, mining, drilling for oil etc.

Reduce the energy requirements as it is more energy efficient than making the material from scratch. This means it is **cheaper** and **reduces the production of greenhouse gases.**

Reduce amount of materials to be disposed of either by **burning** (can generate energy) or by sending to **landfill.** Burning releases carbon dioxide as well as other toxic chemicals if you are burning plastic

• Lifecycle Assessments (LCAs)

Definition of life cycle assessment: a report into the **environmental impacts** of the **life cycle of a product** or material. They are used to compare products and see which will have the least environmentally damaging impact.



Some stages are **objective** as **data** can be obtained regarding the amount of energy used etc. Some stages are difficult to quantify such as effect of pollution so can be **subjective**. It can be manipulated to show the good or bad points of a product so must be aware of the **source** as it may have a **bias.**

Stage	Paper Bag	Plastic Bag
Extracting and processing raw materials	Timber (renewable) pulping – uses **energy, makes lots of waste**	Crude oil (finite) Fractional distillation – **uses energy but little waste**
Manufacturing and Packaging	Rolled and cut by machine – need **energy** Packaged into cardboard boxes	Rolled and cut by machine – need **energy** Packaged into cardboard boxes
Use and operation	Only normally **used once** but use has no environmental impact	**Can be reused** as quite strong use has no environmental impact
Disposal	Can be **recycled** and are **biodegradable** releasing **non-toxic products** as they break down	Can be **recycled.** If thrown away they are **not biodegradable** and will take up space in landfill and may **release toxic compounds**.

You also need to consider the **transport** between all the stages.

09.9 ENVIRONMENTAL SCIENCE.KO.2022-23

• How Humans Use Resources

The Earth and its resources provide us with materials used to provide **warmth, food, shelter and transport.**

Agriculture: used to **supplement natural resources** due to increase demand from **increasing population**

Name of resource	Agricultural supplementation	Synthetic replacement
Wood	forestry	PVC
Cotton	Fertiliser/pesticides	polyesters
Wool	Selective breeding	polyesters
Meat/fish	Selective breeding/antibiotics/factory farming	-
crops	Fertilisers/selective breeding/genetic modification/pesticides	-

Land use: more land needed to provide the above and for building and waste disposal. **Destroys habitats** and **increases pollution.**

• Sustainability

Definition of Sustainability: way of using and developing our **natural resources** so that they met the needs of current and future generations.

How? find ways to **reduce, reuse**, and **recycle finite** resources or to find **renewable** alternatives.

A good example of this is the sustainable development of forests where trees are replanted to replace those that are cut down.

• Burning Fuels

Definition of complete combustion occurs in presence of **excess oxygen** producing **water** and **carbon dioxide**.

Definition of Incomplete combustion occurs when there is a **lack of oxygen**. Instead of producing carbon dioxide the fuels produce **carbon monoxide** and/or **carbon**.

Examples of **different types of combustion** for methane:

$CH_4 + \mathbf{2O_2} \rightarrow \mathbf{CO_2} + 2H_2O$

$CH_4 + \mathbf{1.5O_2} \rightarrow \mathbf{CO} + 2H_2O$

$CH_4 + \mathbf{O_2} \rightarrow \mathbf{C} + 2H_2O$

Other Combustion Products

Some fuels contain **sulfur** which when burnt produces **sulfur dioxide**.

$S + O_2 \rightarrow \mathbf{SO_2}$

When fuels burn at **high temperatures inside car engines** then **nitrogen from the air** can react with **oxygen** to form **oxides of nitrogen**.

$N_2 + O_2 \rightarrow \mathbf{2NO}$

Fuels can also leave behind **unburnt hydrocarbons** which can escape into the atmosphere

• Greenhouse Gases

The **greenhouse effect** is important in **maintaining temperatures** on Earth high enough to **support life**, without it the **average global temperature would be -18°C.** The greenhouse gases are **carbon dioxide, methane and water.**

