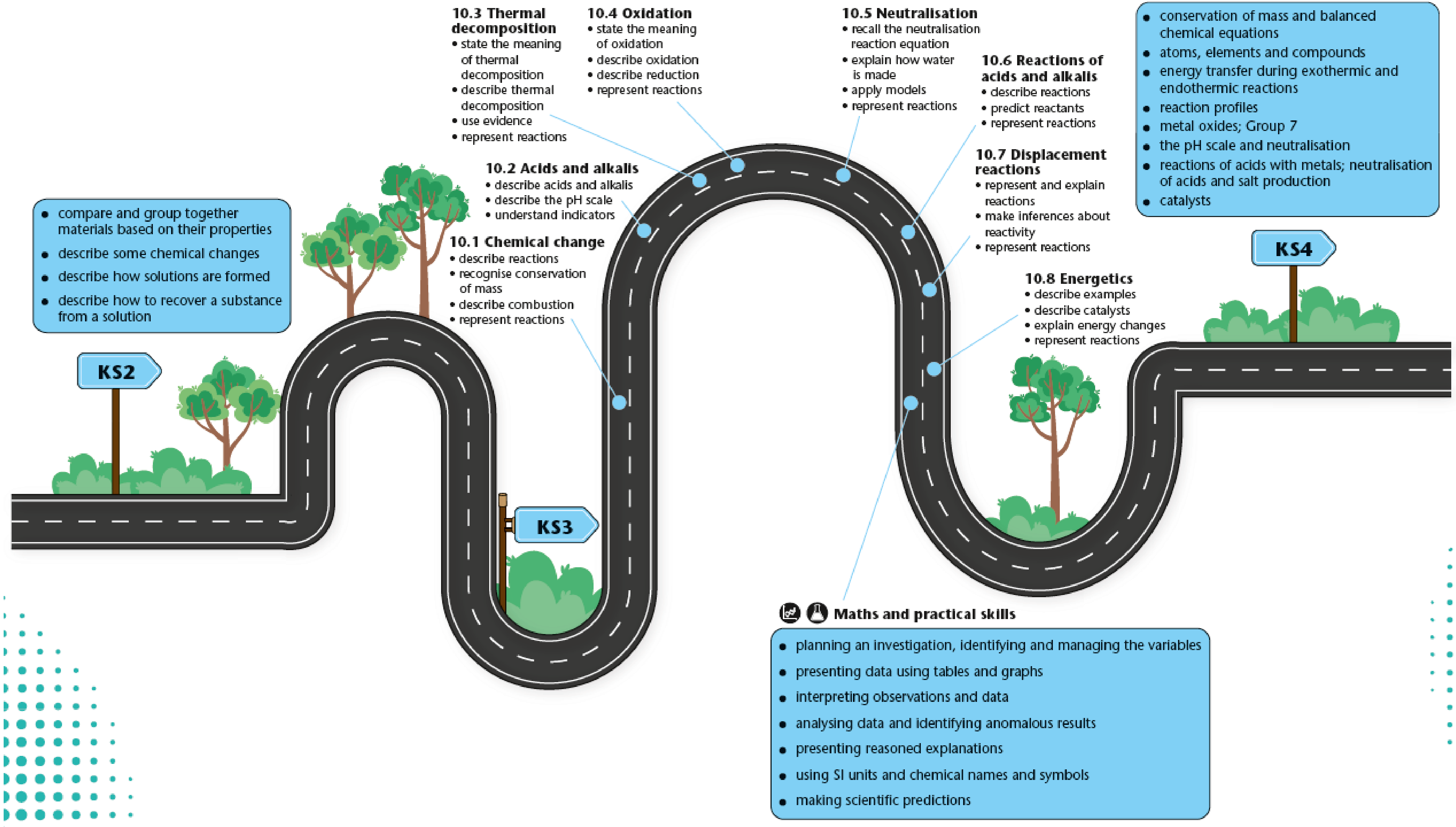
Chemical Energy and Types of Reactions

Road map

Where are you in your learning journey and where are you aiming to be?



Chemical Energy and Types of Reactions

Knowledge organiser

A **chemical reaction** is a change in which new substances are made. During a chemical reaction you may see:

- bubbles of gas
- a change in temperature
- a colour change
- a change in mass.

In any chemical reaction, the total mass of the reactants is the same as the total mass of the products. This is called the law of conservation of mass. Sometimes it may appear that the mass has changed. When this happens, there is normally a gas, either as a reactant or as a product, which accounts for the 'missing' mass.

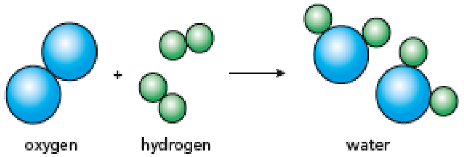
Burning is an example of a chemical reaction. The scientific name for burning is **combustion**. During combustion, a **fuel** reacts with oxygen to make carbon dioxide and water. The reaction releases useful energy. We can summarise combustion using an equation:

fuel + oxygen → carbon dioxide + water

If there is not enough oxygen available to react with all of the fuel, **incomplete combustion** takes place. The reaction has different products.

fuel + oxygen → carbon monoxide + carbon + water

During a chemical reaction, atoms rearrange and join together in a different way. New **products** are formed from the **reactants**. For example, hydrogen and oxygen react together to form water. Hydrogen and oxygen are the reactants and water is the product. One molecule of oxygen reacts with two molecules of hydrogen to form two molecules of water.



Notice that there are the same numbers of oxygen and hydrogen atoms at the start of the reaction as there are at the end of the reaction. They have been rearranged to form a new substance, water.

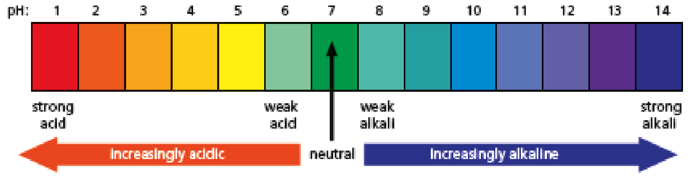
Some of the substances we use at home or in the laboratory are **acids**. Vinegar and lemon juice contain acids. Acids are substances with a **pH** less than 7. Concentrated acids are **corrosive**; dilute acids may be **irritants**. All acids contain the element hydrogen.

Some other substances are **alkalis**. Soap and detergents contain alkalis. Alkalis are substances with a pH greater than 7. Like acids, concentrated alkalis can be corrosive and dilute alkalis may be irritants. All alkalis contain hydroxide particles (**chemical formula** OH).

'Corrosive' hazard sign

'Harmful' hazard sign, which is used for substances that are not corrosive but are irritants.

An **indicator** is a substance that is a different colour in an acid and in an alkali. One example of an indicator is litmus. Litmus solution turns *red in acid* and *blue in alkali*. If a solution is neither an acid nor an alkali, we say it is **neutral.**



Universal indicator turns a range of different colours. The colour depends on whether the substance is an acid or an alkali *and* on how strong or weak it is. Each colour is given a **pH number**. The pH scale is a measure of the acidity or alkalinity of a substance.

Hydrochloric acid is an example of a strong acid, with a pH of 1. Vinegar is an example of a weak acid, with a pH of 3.

Oxidation reactions involve oxygen being added to another substance. This reaction forms compounds called oxides. During the combustion of a metal, oxygen is added to the metal:

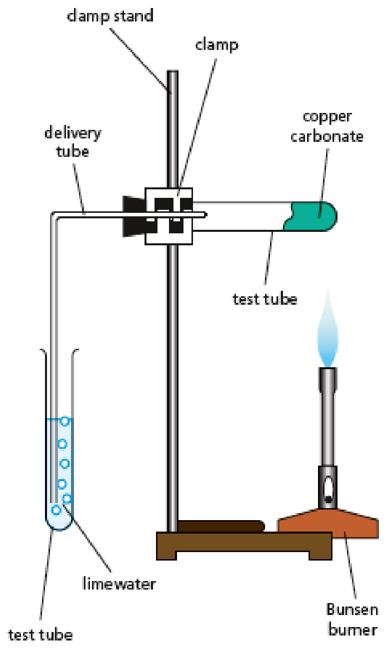
metal + oxygen → metal oxide

The mass of the metal oxide is greater than the mass of the metal because oxygen has been added.

When oxygen is removed from a metal oxide, the reaction is called **reduction**. This is the opposite of oxidation. Carbon can be used to remove oxygen from iron oxide.

Thermal decomposition reactions happen when some substances are heated and break down into simpler products. No new substances are added. When carbonates decompose, they produce a metal oxide and carbon dioxide:

metal carbonate → metal oxide + carbon dioxide



Key vocabulary	
acid	a substance that will neutralise a base; has a pH lower than 7
alkali	a base that is soluble in water; has a pH above 7
chemical formula	chemical symbols and numbers that show how many atoms of which elements are contained in a molecule of an element or compound
chemical reaction	a process in which one or more substances are changed into others, by the rearrangement of their atoms
combustion	the reaction of a fuel with oxygen that transfers thermal energy to the surroundings
conserved	when the quantity of something does not change after a process takes place
corrosive	can destroy skin and attack metal if spilled
fuel	any material that can be burned to release energy
incomplete combustion	when there is not enough oxygen available to react with all of a fuel during combustion
indicator	chemical that is a different colour in an alkali and an acid; used to identify whether an unknown solution is acidic or alkaline
irritant	a substance that causes the skin to become red, blistered and itchy
neutral	has a pH of 7
oxidation	a reaction in which a substance combines with oxygen
pH	a number from 1 to 14 on the pH scale of acidity and alkalinity
product	(of a chemical reaction) a substance made in a chemical reaction
reactant	a starting substance in a chemical reaction
reduction	a reaction in which oxygen is removed from a compound
thermal decomposition	a chemical change caused by heating, when one substance is changed into at least two new substances
universal indicator	an indicator that turns a range of different colours; each colour indicates a different pH value

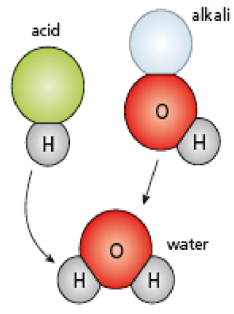
Chemical Energy and Types of Reactions

Knowledge organiser

A neutral substance has pH 7. It is made when an acid and alkali exactly neutralise one another. This is called **neutralisation**. Neutralisation is a chemical reaction; new products are formed.

acid + alkali → salt + water

Water is a product of the neutralisation reaction between acids and alkalis. The hydrogen from the acid combines with the hydroxide from the alkali to form water.



Acids react with bases to produce a **salt** and water. This is similar to the reaction you saw above between an acid and an alkali.

acid + base → salt + water

Salts are also formed in other reactions that involve acids. Acids react with metals to form a salt and hydrogen gas.

acid + metal → salt + hydrogen

Acids react with metal carbonates to form a salt, water and carbon dioxide.

acid + metal carbonate → salt + water + carbon dioxide

The reactivity series of metals places metals in order of their reactivity. It also includes two non-metals: hydrogen and carbon.

Most reactive

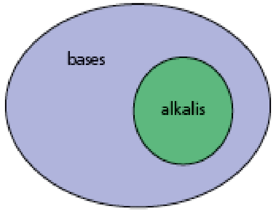
K	potassium
Na	sodium
Ca	calcium
Mg	magnesium
Al	aluminium
C	carbon
Zn	zinc
Fe	iron
Sn	tin
Pb	lead
H	hydrogen
Cu	copper
Ag	silver
Au	gold
Pt	platinum

Least reactive

In a **displacement reaction** a more **reactive** substance displaces (pushes out) a less reactive substance from a compound. An example is when iron is added to a copper sulfate solution. Iron is more reactive than copper. A chemical change occurs – iron displaces the copper to make iron sulfate:

iron + copper sulfate → iron sulfate + copper

A **base** is any substance that neutralises an acid to produce a salt and water. An alkali is a soluble base – one that dissolves in water. Therefore, all alkalis are bases, but not all bases are alkalis. Metal oxides, metal hydroxides and metal carbonates are all examples of bases.



The name of a salt has two parts. The first part comes from the reactant that is not the acid; it is often a metal. For example, the alkali sodium hydroxide forms salts that start with 'sodium'. The end part of the name comes from the acid. For example, a salt formed from sulfuric acid and sodium hydroxide is called 'sodium sulfate'.

Acid used in reaction	Forms salts that end in…
hydrochloric acid	chloride
sulfuric acid	sulfate
nitric acid	nitrate

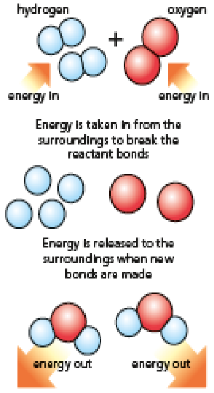
Acids contain hydrogen. When reactive metals react with acids, a displacement reaction occurs and hydrogen is displaced from the acid. If a metal is above hydrogen in the reactivity series, it will react to displace hydrogen. For example:

zinc + hydrochloric acid → zinc chloride + hydrogen

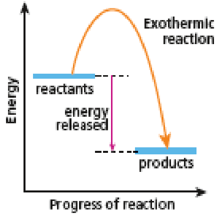
Non-metals also undergo displacement reactions. Chlorine and iodine are non-metals. Chlorine is more reactive than iodine. When chlorine gas is passed through sodium iodide solution, the chlorine displaces the iodine:

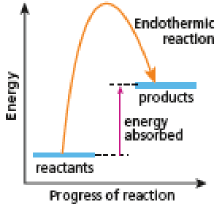
chlorine + sodium iodide → sodium chloride + iodine

In a chemical reaction, existing **chemical bonds** are broken and new ones are made. Energy is needed to break chemical bonds; energy is released when new chemical bonds are made. The balance between these two processes explains why some reactions are endothermic and others are exothermic. If more energy is needed for **bond breaking** than is released in **bond making**, the reaction is endothermic. If less energy is needed for bond-breaking than is released in bond-making, the reaction is exothermic.



In some reactions, like combustion, there is an **energy transfer** to the surroundings – these are known as **exothermic reactions**, which cause the temperature of the surroundings to increase. Other reactions, like thermal decomposition, take energy from their surroundings – these are known as **endothermic reactions**, which cause the temperature of the surroundings to decrease. An energy profile diagram shows the energy changes taking place during exothermic and endothermic reactions.





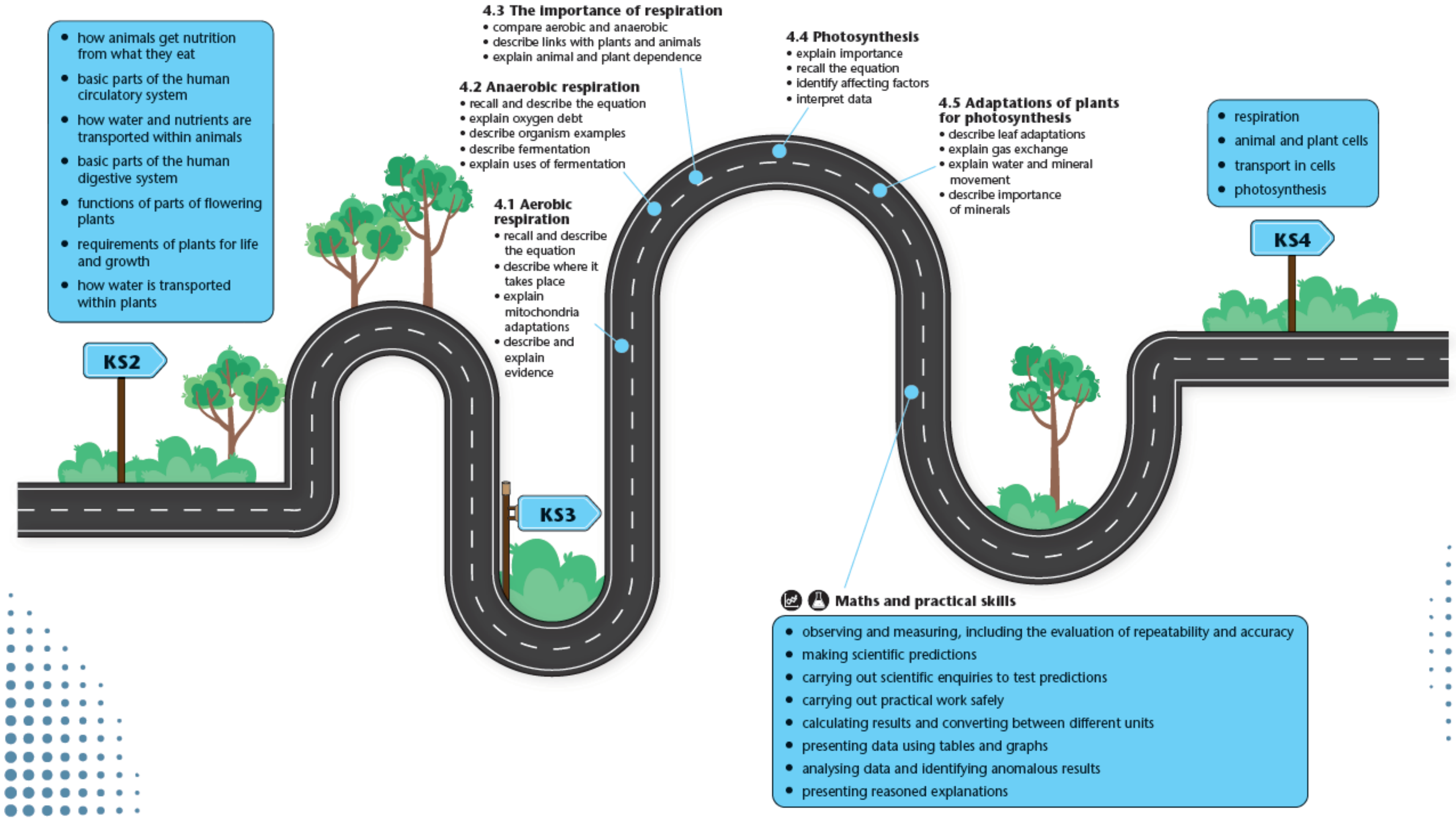
A **catalyst** is a substance that is added to a chemical reaction to make the reaction faster. Catalysts are not changed by the reaction – they alter the **rate of reaction**. Most catalysts provide an alternative 'pathway' for the reaction that lowers the amount of energy needed for the reaction to proceed.

Key vocabulary	
base	a substance that will neutralise an acid
bond breaking	when a chemical bond is broken by overcoming the force of attraction between particles; energy is transferred in from the surroundings
bond making	when a chemical bond is made by the force of attraction between particles; energy is transferred out to the surroundings
catalyst	substance that speeds up a chemical reaction
chemical bond	the force of attraction between two atoms
displacement reaction	a chemical reaction in which one substance takes the place of another in a compound
endothermic reaction	a chemical reaction in which energy is taken in, causing a cooling of the surroundings
energy transfer	the passing on of energy from one energy store to another energy store
exothermic reaction	a chemical reaction in which energy is given out, causing a warming of the surroundings
neutralisation	to make a substance neutral (pH 7) by adding an acid or a base
rate	the number of times something happens in a unit of time, such as a second
rate of reaction	a measure of the speed of a reaction; for example, the number of molecules of product produced over a set time
reactive	inclined to react in a chemical reaction; some substances are more reactive than others
salt	a substance formed when an acid reacts with a base, a metal or a metal carbonate

Respiration and photosynthesis

Road map

Where are you in your learning journey and where are you aiming to be?



Respiration and photosynthesis

Knowledge organiser

Respiration happens in every living cell. It is the chemical reaction that releases energy from **glucose**. All living things – animals, plants and microbes (microorganisms) – need energy. Some uses are given on the right.

Animals need energy:	Plants need energy:
to grow and repair tissues	to grow and repair tissues
to reproduce	to reproduce
to keep the body at a suitable and fairly constant temperature	to transport water
to contract muscles in order to move	to absorb nutrients

Aerobic respiration uses oxygen:

glucose + oxygen → carbon dioxide + water (+ energy)

glucose	oxygen	carbon dioxide + water	(+ energy)
Animals get glucose from digestion of food. Glucose is carried by the blood from the small intestine to all cells of the body.	Animals get oxygen from breathing. Oxygen is carried by the blood from the alveoli in the lungs to all cells of the body.	In animals, the waste carbon dioxide and water are carried by the blood from the cells to the lungs, where it is breathed out.	The energy released is needed for many life processes in animals and plants.
Plants make glucose by the process of photosynthesis.	Plants get oxygen by diffusion from the air or by photosynthesis.	In plants, the waste carbon dioxide and water diffuse from the leaves into the air or are used in photosynthesis.	

Anaerobic respiration takes place when there is not enough oxygen for aerobic respiration or when energy is needed to be released quickly. In animals, for example, **aerobic respiration** (in mitochondria) switches to anaerobic respiration (in the cytoplasm) during vigorous exercise. Even while there is still some oxygen left in your body, anaerobic respiration may begin, as it releases energy quickly.

The process differs in animals and plants and microbes.

In animals: glucose → lactic acid (+ energy) — oxygen needed to get rid of the **lactic acid** is the '**oxygen debt**'

In plants and microbes: glucose → ethanol + carbon dioxide (+ energy) — this is called **fermentation**

Comparing aerobic and anaerobic respiration:

	Location	Reactants	Products	Energy generated
aerobic respiration	mitochondria	glucose and oxygen	carbon dioxide and water	more energy than anaerobic but not generated as quickly
anaerobic respiration	cytoplasm	glucose	animals – lactic acid plants and microbes (fermentation) – ethanol and carbon dioxide	less energy than aerobic but generated more quickly

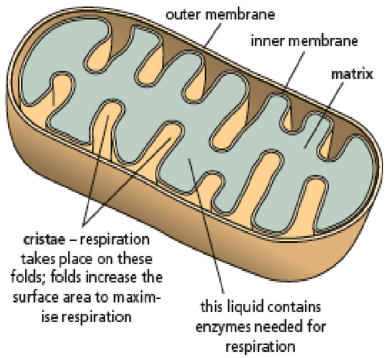
Fermentation (anaerobic respiration) by yeast is useful to humans.

- **brewing** – in beer and wine making, **ethanol** is the useful product. The type of drink made depends on the source of sugar, for example, grapes for wine, hops and barley for beer.
- **baking** – in bread making, carbon dioxide is the useful product as it causes the bread to rise.

In brewing and baking, water is first added to dried yeast to activate it. Sugar is then added as the reactant for respiration.

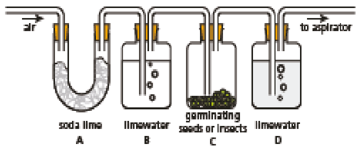
Glucose and oxygen are the **reactants**.
Carbon dioxide and water are the **products**.

Aerobic respiration takes place in cell organelles called **mitochondria**. These are sausage-shaped and found in most animal and plant cells. Their structure is adapted to carry out their function.



We can use experiments to show that animals and plants produce water and carbon dioxide, the products of respiration.

- Water – when we breathe onto a cold mirror or window, water vapour condenses onto the cold surface. If a plant is grown in a plastic bag, water vapour condenses inside the bag.
- Carbon dioxide – in the set-up below, **soda lime** absorbs carbon dioxide, **limewater** tests for carbon dioxide. B stays clear showing no carbon dioxide; D turns cloudy showing carbon dioxide has been produced.



Glucose can be stored in organisms. It can then be used to release energy as and when needed.

In the animal and human body, glucose is stored:

- as **glycogen** in muscles and the liver
- as fat.

In plants, glucose is stored as starch.

Key vocabulary	
aerobic respiration	respiration involving oxygen
anaerobic respiration	respiration without using oxygen
baking	cooking with dry heat, for example, in an oven as is done with bread and pastries
brewing	the production of beer using fermentation
cristae	the folds of the inner membrane of a mitochondrion where respiration takes place
ethanol	an alcohol produced during anaerobic respiration in plants and microbes
fermentation	a type of anaerobic respiration taking place in plants and some microbes
glucose	a simple organic sugar molecule, used in respiration
glycogen	organic glucose molecules linked in a long chain; a storage molecule
lactic acid	the substance produced in anaerobic respiration in animals
limewater	a solution used to test for the presence of carbon dioxide
matrix	the liquid inside a mitochondrion which contains the enzymes needed for respiration
mitochondria	an organelle found in most animal and plant cells where respiration is carried out
oxygen debt	the oxygen needed to break down lactic acid produced as a result of vigorous exercise
products	substances that are produced by a chemical process or reaction
reactants	substances that react in a chemical process
respiration	the process in living things in which energy is released from glucose
soda lime	a chemical that absorbs carbon dioxide

Respiration and photosynthesis

Knowledge organiser

Life on Earth and human activities are dependent on plants for many reasons:

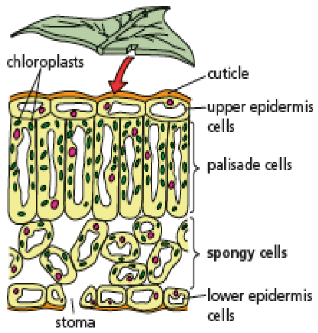
- food (green plants are at the start of all feeding relationships)
- raw materials for fabrics and building
- fuel
- medicines
- decorating homes, gardens, parks
- green plants help to maintain the balance of carbon dioxide and oxygen in the atmosphere.

Comparing photosynthesis and respiration.

- Photosynthesis takes place in green plants; respiration takes place in both plants and animals.
- The products of photosynthesis (glucose and oxygen) are the reactants of aerobic respiration.
- The products of aerobic respiration (carbon dioxide and water) are the reactants of photosynthesis.
- Photosynthesis requires energy (from light); respiration releases energy.

Photosynthesis takes place in green leaves. **Chlorophyll** is a green pigment and is found in organelles called **chloroplasts** in some plant cells. Leaves are adapted for photosynthesis.

Adaptation	Function
waxy and waterproof **cuticle**	prevents water loss
transparent layer below cuticle	allows light through
palisade cells packed with chloroplasts	increase photosynthesis
stomata on underside	open and close to control gas exchange
air spaces	allow gases to move inside the leaf



Photosynthesis is the reaction used by green plants to make the carbohydrate glucose using light energy.

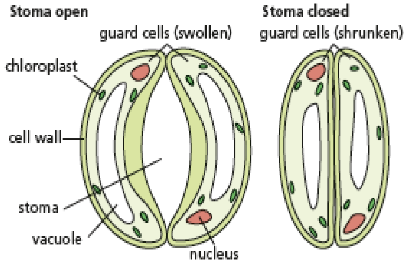
carbon dioxide + water —light→ glucose + oxygen

reactants → *products*

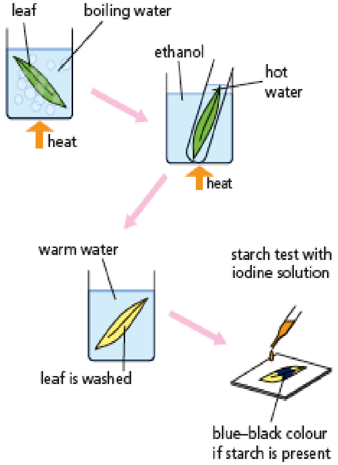
Stomata are opened and closed by specialised **guard cells**. Through the stomata:

- gas exchange happens – gases pass in and out of the leaf
- water can be lost.

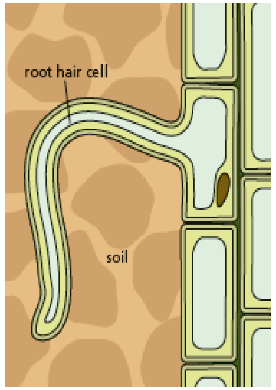
Stomata close when water levels are low and at night (as there is no sunlight for photosynthesis).



Glucose from photosynthesis is stored as starch. Testing leaves for starch with **iodine** shows whether or not a plant has been photosynthesising. The experimental steps are shown below.



Water and **minerals** move into a plant through the roots from the soil. **Root hair cells** do not contain chloroplasts because they are not exposed to light. The cells are adapted to their function by having extensions called root hairs, to increase the surface area for absorption.



Some minerals are essential nutrients to keep plants healthy. If they are missing or deficient the plant's health is affected.

Mineral	Effect of deficiency
nitrates (contain nitrogen)	poor growth and yellow leaves
magnesium	cannot make chlorophyll
phosphates (contain phosphorus)	poor root growth

Plants have tissues that are specialised to transport substances.

1. Water moves up the plant from the roots to the leaves through **xylem**.
2. Glucose made by photosynthesis moves from the leaves and around the plant through **phloem**.

Transpiration is the loss of water from a leaf. Most water is lost in hot, dry, windy conditions. Leaves can be adapted to reduce water loss by:

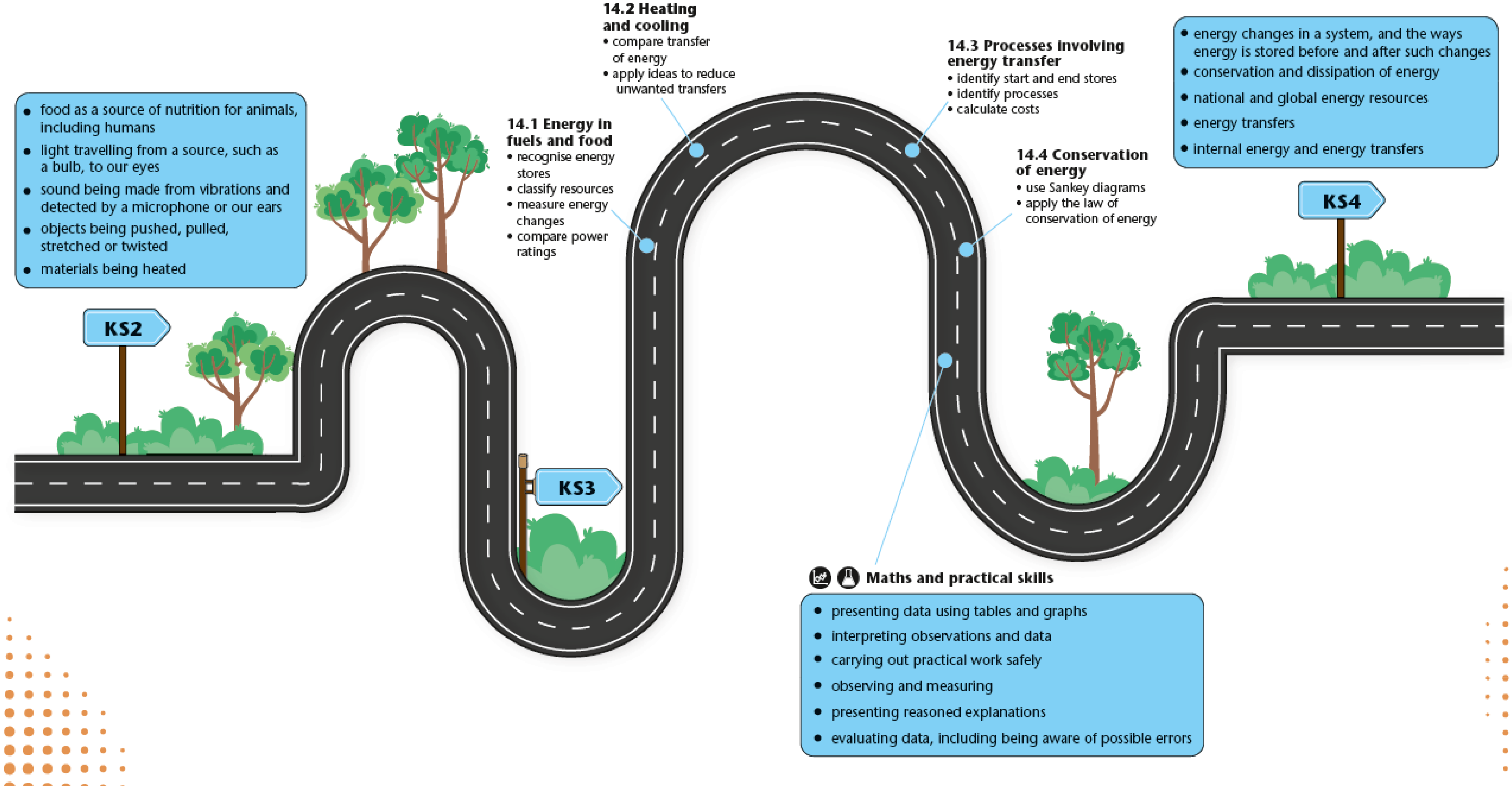
- having a thick waxy cuticle
- having narrow, curled or folded leaves to reduce their surface area
- closing their stomata.

Key vocabulary	
chlorophyll	the green pigment in plants that traps sunlight for photosynthesis
chloroplasts	organelles within some plant cells that contain chlorophyll
cuticle	the waxy, waterproof outer layer of a leaf
guard cells	cells that open and close the stomata
iodine	a chemical used to test for the presence of starch
minerals	elements such as iron and calcium needed to keep living things healthy
palisade cell	a plant leaf cell that is long and narrow and packed with chloroplasts
phloem	a tissue made up of long tubes that transport glucose made in the leaves to other parts of the plant
photosynthesis	a process carried out by green plants; light energy, carbon dioxide and water react to produce glucose and oxygen
rate of photosynthesis	the measure of how much photosynthesis takes place in a set time
spongy cells	plant leaf cells that have large spaces around them to allow gas exchange
starch	a large molecule made by plants as a way to store food (glucose)
stomata (singular: stoma)	a minute pore in the lower surface of a leaf
root hair cell	a specialised cell in roots of plants, hair-like extensions that provide a large surface area
transpiration	the movement of water in plants as it is taken up through the roots and released from the leaves as water vapour
xylem	a tissue made of cells that form a long tube through the plant to transport water and minerals from the roots

Work, Heating and Cooling

Road map

Where are you in your learning journey and where are you aiming to be?



Work, Heating and Cooling

Knowledge organiser

Stored **energy** is called **potential energy**. Energy can be stored in several different ways:

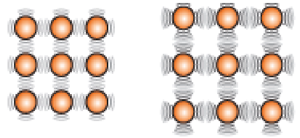
- **chemical potential energy** (for example, in **fuels** and food)
- **elastic potential energy** (for example, in a stretched or compressed spring)
- **gravitational potential energy** (for example, an apple on a tree)
- **kinetic energy** (for example, a moving car)
- **thermal energy** (for example, a hot cup of tea) – it is responsible for the temperature of an object.

Energy transfer is the passing on of energy from one store to another. Energy can be transferred between stores in various ways including heating, doing mechanical work, by an electrical current or by waves.

We measure energy in **joules (J)** or **kilojoules (kJ)**.

Power is the rate at which energy is transferred. It is measured in **watts (W)** and **kilowatts (kW)**.

Different **foods** contain different amounts of energy per gram.



Thermal (heat) energy is transferred through a material by **conduction**. The vibrating particles within the material transfer energy by colliding with their neighbours. A material that conducts heat is called a **thermal conductor**, a material that does not is called a **thermal insulator**.

Electricity can be generated using **renewable energy** sources, such as the wind, or **non-renewable energy** sources, such as gas.

Gas and electricity companies calculate the cost of home energy use using the unit **kilowatt-hours (kW h)**.

The cost of using an electrical appliance can be calculated using the equation:

cost = power (kW) × time (hours) × price (per kWh)

Key vocabulary

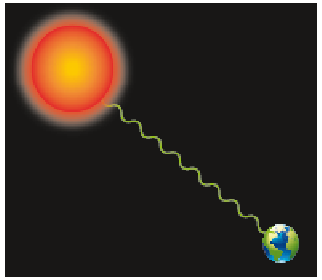
conduction	the transfer of energy by passing on energy to nearby particles
energy	the potential to do work or produce heat
energy transfer	the passing on of energy from one energy store to another
food	a substance that provides living things with nutrients and energy
fuel	a material that is burned to release its stored energy
joule (J), kilojoule (kJ)	unit of energy; 1000 J = 1 kJ
kilowatt-hour (kW h)	the energy transferred in 1 h by an electrical appliance with a power rating of 1 kW
non-renewable energy	energy from a source, such as a fossil fuel, that will run out because it cannot be replaced quickly enough
power	amount of energy that something transfers each second; measured in watts (W)
radiation	energy given out in the form of a wave; it can pass through a vacuum
renewable energy	energy from a source that will not run out, such as the sun or wind
temperature	the measure of how hot or cold an object is; unit is degrees Celsius (°C)
thermal conductor	a material that allows energy to pass through it quickly by the process of thermal conduction
thermal insulator	a material that does not allow energy to pass through it quickly by the process of thermal conduction
watt (W), kilowatt (kW)	unit of power; 1000 W = 1 kW; 1 W is equal to a joule per second (1 J/s)

When energy is transferred, not all of the energy is useful for the intended purpose. We say that any energy transferred to a store where we cannot use it is **wasted energy**. This can happen, for example, when friction heats up two surfaces that rub together, or when a hot object heats up the air around it.

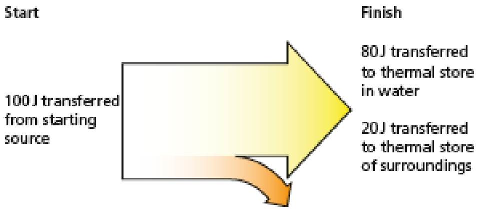
When energy is being transferred, we can keep track of the increase or decrease in the amounts of energy in each store by drawing an **energy transfer diagram**.

Whenever energy is transferred no energy is ever 'lost' or 'used up'. The quantity of energy stored before the change is the same as the quantity stored after the change. This is called the **law of conservation of energy**.

Thermal (heat) energy can be transferred from a hotter object to a cooler one by thermal **radiation**. The energy is transferred as a wave, and does not require the presence of particles to travel through.



The energy supplied to and the energy outputs from a system can be represented on a **Sankey diagram**. This shows which of the outputs are useful. The width of each arrow represents how much energy is transferred, so the diagram also shows the proportion of the input energy that is useful and that the total amount of energy is conserved.



Key vocabulary

chemical potential energy	the energy store that is emptied during chemical reactions
elastic potential energy	the energy store of an elastic object when it is stretched or compressed
energy transfer diagram	a diagram with arrows showing how energy is transferred between energy stores
gravitational potential energy	the energy store of an object because of its height above the ground
kinetic energy	the energy stored in a moving object
law of conservation of energy	energy cannot be created or destroyed, only stored or transferred; this means that the total energy is the same before and after a change
Sankey diagram	an energy transfer diagram that shows what proportion of the input energy is transferred as useful or as wasted output
thermal energy	the energy store filled when an object is warmed up

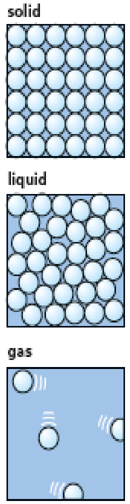
Work, Heating and Cooling

Knowledge organiser

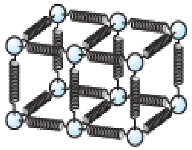
All **matter** is made from **particles**, which are arranged in the different **states of matter**.

- In solids, the particles vibrate in their fixed positions.
- In liquids, the particles move randomly from their positions, but are always in contact with other particles.
- In gases, the particles move about randomly and very quickly, widely separated but colliding with other particles.

Temperature affects how quickly the particles move. At higher temperatures, particles in a solid vibrate faster, while in liquids and gases particles move around faster.



The particles in a solid have very strong, attractive forces between them, which hold the particles in their positions.

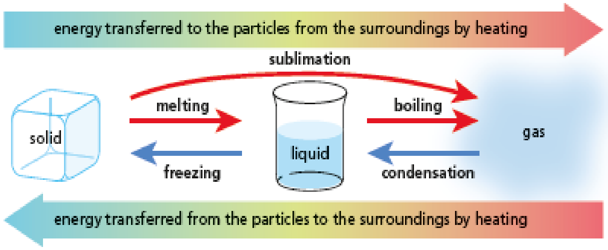


The forces between the particles in liquids are still strong, but not as strong as in solids. Gases have the weakest forces between particles.

When gas particles or liquid particles move, they collide with other particles and also with the sides of the container they are in. **Pressure** is a measure of the average force of these collisions over the area of the container's sides. The standard units of pressure are **kilopascals (kPa)**.

State of matter	solids	liquids	gases
Shape	fixed shape and cannot flow because the particles cannot move from their fixed positions	flow and take the shape of their container because the particles can move past each other	flow and fill their container because the particles can move around quickly in any direction
Compression	cannot be **compressed** as the particles are close together in a fixed position	cannot be compressed because their particles are close together and there are no spaces for them to move into	can be compressed because the particles are far apart with space between them for particles to move into

The change from a solid to a liquid or a gas, and from a liquid to a gas, are reversible changes. They are called **physical changes**. When materials are heated or cooled, they may change from one state to another. Water freezes to become ice at 0 °C and boils to become a gas at 100 °C.

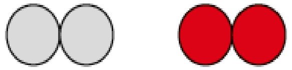


Boiling only happens at the **boiling point**, and the whole liquid turns into a gas. The particles gain enough energy to leave the liquid.

Evaporation occurs at any temperature between the melting point of a liquid and its boiling point. It only happens at the surface of the liquid. Some of the particles gain enough energy to leave the surrounding particles and become a vapour.

Atoms are the smallest parts of all substances. We can represent an atom by writing its element name, writing a symbol, or drawing a simple circular particle. John Dalton was the first person to propose using particles to represent atoms.

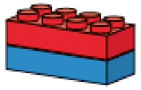
Some atoms can chemically bond together to form **molecules**. Here is a molecule of hydrogen and a molecule of oxygen.



Elements contain only one type of atom. Most elements are metals. Each element is identified by a unique symbol, which always begins with a capital letter.

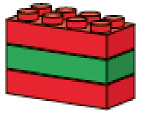
Compounds are made from the atoms of more than one element, chemically bonded together. Compounds have different properties from the original elements.

We use the chemical symbols of the elements to write the **chemical formula** of the compound, which represents the **ratio** of atoms in each unit of the compound.



1 red brick and 1 blue brick, the ratio is 1:1

This model could represent one unit of the compound copper oxide, CuO



2 red bricks and 1 green brick, the ratio is 2:1

This model could represent one molecule of the compound carbon dioxide, CO_2

Key vocabulary	
atom	the basic 'building block' of an element; it cannot be chemically broken down
boiling	the process that happens when a liquid changes state and turns into a gas, by reaching its boiling point
boiling point	the temperature at which a liquid changes state to a gas (or at which a gaseous substance condenses)
chemical formula	chemical symbols and numbers that show which elements, and how many atoms of each, a compound is made up of
collision	when objects hit each other with force
compound	atoms of more than one element chemically bonded together
compress	to make smaller by squashing or pushing together
condensation	the process that happens when a gas changes into a liquid when the temperature drops to the boiling point; for example, when water vapour condenses to form liquid water
element	a substance made of only one type of atom
evaporation	the process that happens when a liquid changes to a gas at the surface of the liquid; for example, when water evaporates to form water vapour
freezing	the process in which a liquid turns into a solid by being cooled to its melting point; for example, when water freezes to form ice
kilopascal (kPa)	unit of pressure
matter	anything that takes up space and has mass
melting	the process in which a solid turns into a liquid by being heated to its melting point; for example, when ice melts to form water
molecule	two or more atoms held together by strong chemical bonds
particle	a very small part of a material, such as an atom or a molecule
particle model	a scientific model in which all matter is made of a large number of very small particles; used to explain the properties of solids, liquids and gases
physical change	physical changes are reversible and include dissolving and changes from one state (solid, liquid or gas) to another
pressure	the average force on a certain area
ratio	a link between two values; for example, if the first value is twice the second value, the ratio is 2:1
state of matter	solid, liquid or gas
sublimation	the process that happens when a solid turns into a gas when heated, without becoming a liquid first
temperature	a measure of how hot an object is; the unit is normally degrees Celsius (°C)
viscosity	the resistance to flow

Work, Heating and Cooling

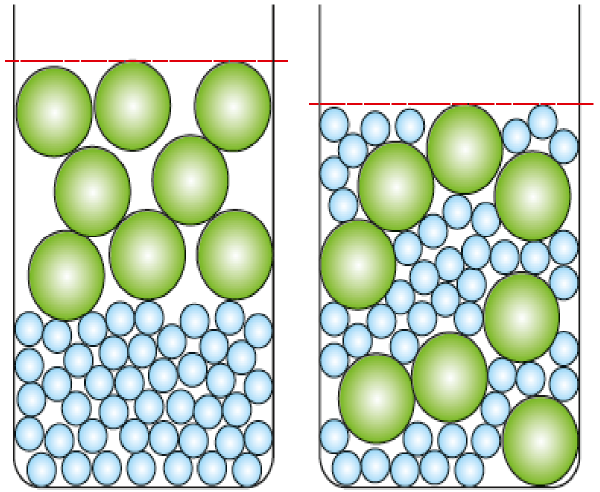
Knowledge organiser

The law of **conservation of mass** means that matter cannot be destroyed or created, only transformed. This means that when a reaction takes place, the mass of the reactants always equals the mass of the products. This is also true when substances change state, when solutions are mixed together, or if a solute is dissolved in a solvent to form a solution.

Sometimes there appears to be a change in mass during a physical or **chemical change**. This change in mass can usually be explained because one of the reactants or products is a gas.

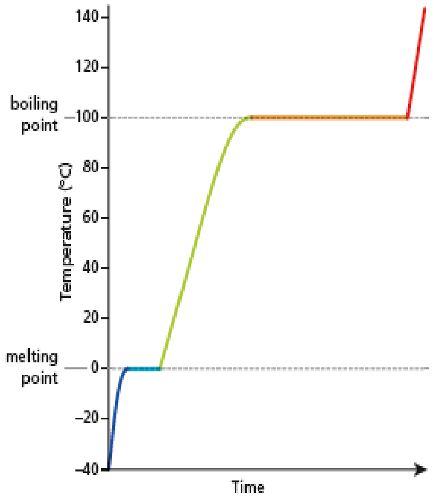
In a chemical reaction, the mass of the products may be less than expected because one of the products is a gas that has escaped into the surrounding air. If the mass of the products is more than expected, then one of the reactants is a gas. The gas atoms have chemically bonded to one of the other reactants.

When alcohol and water are mixed the volume is less, but the mass stays the same. This is because there are the same number of particles, but the mixture takes up less room



When a solid is heated, its temperature increases until it reaches its **melting point**. At the melting point, all the **energy transferred** by heating is used to overcome the forces between the particles, until the solid changes state. The temperature remains constant until all the solid has changed state. This 'extra heat' needed for the change of state is called **latent heat**.

This graph shows what happens to the temperature as an ice cube is heated. At the melting point, 0 °C, the temperature remains constant until all the substance has changed state from a solid to a liquid. The temperature also remains constant at the boiling point of 100 °C, until all the water has changed state from a liquid to a gas.



Heating causes solids, liquids and gases to **expand**. This is called **thermal expansion**. It means they take up more space when they are hot compared to when they are cold. Gases expand more than solids and liquids.

Diffusion is the movement of particles from an area of high **concentration** to an area of low concentration, until the concentration is equal throughout.

Diffusion happens because of the movement of particles in a gas or a liquid. There is hardly any diffusion in solids because the particles cannot move freely. Gas particles move faster and further than liquid particles, so diffusion in gases occurs faster than in liquids.

Key vocabulary	
accurate	an accurate measurement is one that is close to the true value
chemical change	an irreversible change caused when one substance combines with another to form a new substance, or one substance breaks down to form two or more others
concentration	a measure of the number of particles in a certain volume or space
concentration gradient	the difference in concentration between two areas
conservation of mass	matter cannot be destroyed or created, only transformed; this means the total mass does not change during physical changes or chemical reactions
diffusion	the movement of particles from a higher concentration to a lower concentration
energy transfer	the passing on of energy from one energy store to another
expand	get bigger
latent heat	the heat needed to change the state of a substance
melting point	the temperature at which a solid changes state to a liquid (or a liquid substance freezes)
precise	measurements are precise if they are clustered together around the mean
repeatable	measurements are repeatable when the same person carries out the same experiment under the same conditions and gets similar results
thermal expansion	when particles in a solid or liquid gain enough energy to occupy more space
true value	the actual value that a measurement should be