Hazards

- A **hazard** is something that can cause harm.
- Chemicals are labelled with hazard symbols to warn people of potential dangers.
- Some common hazard symbols are:

Risk WS

- A **risk** is the chance that a hazard will actually cause harm.
- Risks can be reduced by taking **precautions**. E.g. wearing eye protection to prevent chemicals splashing in your eyes or tying long hair back to prevent it catching fire in a Bunsen flame.

Acids

- Common substances at home that contain acids include: citric acid, vinegar, fizzy drinks and car battery acid.
- Acids have a sour taste.
- Most concentrated acids are **corrosive**. If they are added to water they become more **dilute**. Dilute acids are less hazardous. Many dilute acids are **irritant**.

Alkalis

- Common substances at home that contain alkalis include: toothpaste, drain cleaner, oven cleaner.
- Many alkalis are metal hydroxide solutions.
- An alkali can be described as a soluble base. A base is any substance, soluble or insoluble, that neutralises an acid forming a salt and water.

Indicators

- Indicators change colour and can be used to detect acids, alkalis and neutral solutions.
- Litmus is a common indicator.

Solution	Colour of litmus
acid	red
neutral	purple
alkali	blue

pH scale

- A numbered scale from 1 to 14.
- Acids have a pH less than 7. The lower the pH, the more acidic the substance is. The lower the pH, the more hazardous the acid is.
- Neutral solutions have pH 7.
- Alkalis have a pH more than 7. The higher the pH, the more alkaline the substance is. The higher the pH, the more hazardous the alkali is.

strong acid			weak acid			neutral	weak alkali			strong alkali			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
stomach acid		vinegar	fizzy drinks		skin	pure water	indigestion powder			washing powder			oven cleaner
		lemon juice			milk		toothpaste						

Neutralisation

- This is a reaction between an acid and an alkali.

acid + alkali → salt + water

- It is also a reaction between an acid and a base.

acid + base → salt + water

Word equation

- This summarises a reaction by writing the names of the substances you start with and the names of the new substances that are made.
- **Reactants** are the substances you start with and are written on the left side of the word equation.
- **Products** are the new substances that are made and are written on the right side of the word equation.
- There is an arrow between the reactants and products. The arrow means 'react to form'. Do not write an equals sign, =.
- For example

hydrochloric acid + sodium hydroxide → sodium chloride + water

Hydrochloric acid and sodium hydroxide are the reactants.

Sodium chloride and water are the products.

Notice the arrow between the reactants and the products.

Salts

- Salts are made when an acid reacts with an alkali or a base.
- Salts names are made of two words.
- The first part of the name of the salt is the same as the metal in the alkali or base.
- The second part of the name of the salt comes from the acid.

Acid	Second part of the name of the salt	Example
hydrochloric acid	chloride	Zinc chloride is made from zinc oxide and hydrochloric acid
nitric acid	nitrate	Magnesium nitrate is made from magnesium oxide and nitric acid
sulfuric acid	sulfate	Copper sulfate is made from copper oxide and sulfuric acid

Neutralisation in everyday life

- Antacids are indigestion remedies. People take these medicines if they have indigestion caused by too much acid in the stomach. The antacid contains a base that neutralises the extra acid.
- Soil can become too acidic for some crops to grow. Farmers spread lime (a base) on the soil to neutralise the acid.
- Toothpaste contains a mild alkali to neutralise the acid in our mouths.
- Alkalis are used to neutralise the acidic gases coming out of power stations.
- Sulfuric acid reacts with iron oxide in rust and removes it from the surface of an object.

Food

We need to eat a wide variety of foods to get all the food substances that we need. When we do this, we are said to have a **balanced diet**. Carbohydrates, proteins, fats and oils (lipids), vitamins and minerals are **nutrients**, which means that they provide the raw materials for making other substances that the body needs.

Substance needed	Examples	Why it is needed	Good sources
carbohydrate	starch, sugars	for energy (in respiration)	pasta, bread, rice, potatoes
protein		for growth and repair (building new substances)	meat, fish, beans
vitamins	vitamin C	for health	fruits and vegetables (e.g. oranges contain lots of vitamin C)
minerals	calcium	for health	fruits, vegetables and dairy products (e.g. milk contains calcium)
fibre		for health (helps to stop constipation)	wholemeal bread, wholegrain rice, celery and other fibrous vegetables
water		for health (water dissolves substances and fills up cells)	

We can do tests to find out which substances are in foods. For example, starch makes iodine solution go a blue-black colour.

Nutrition information labels on foods tell us what the food contains. The labels also tell us how much energy is stored in the substances that make up the food. The amount of energy is measured in **kilojoules (kJ)**. The amount of energy a person needs in a day depends on:

- levels of activity (more active people need more energy)
- age (teenagers need more energy from food than adults do)
- whether the person is a girl or a boy (boys need more energy than girls).

Food labels may also have health claims on them, which use persuasive language.

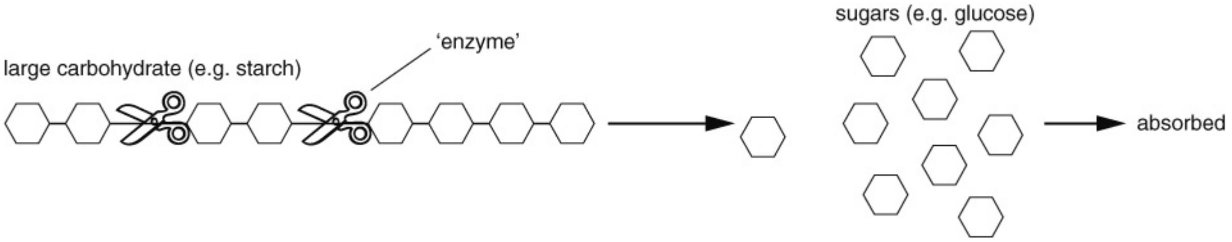
Eating too much or too little can cause problems. Too much fat may cause **heart disease** and can make people overweight. Very overweight people are **obese**.

People starve and become weak if they eat too little. **Starvation** and obesity are both forms of **malnutrition**. Other forms include **deficiency diseases** such as **scurvy**, which is due to a lack of vitamin C.

Digestion

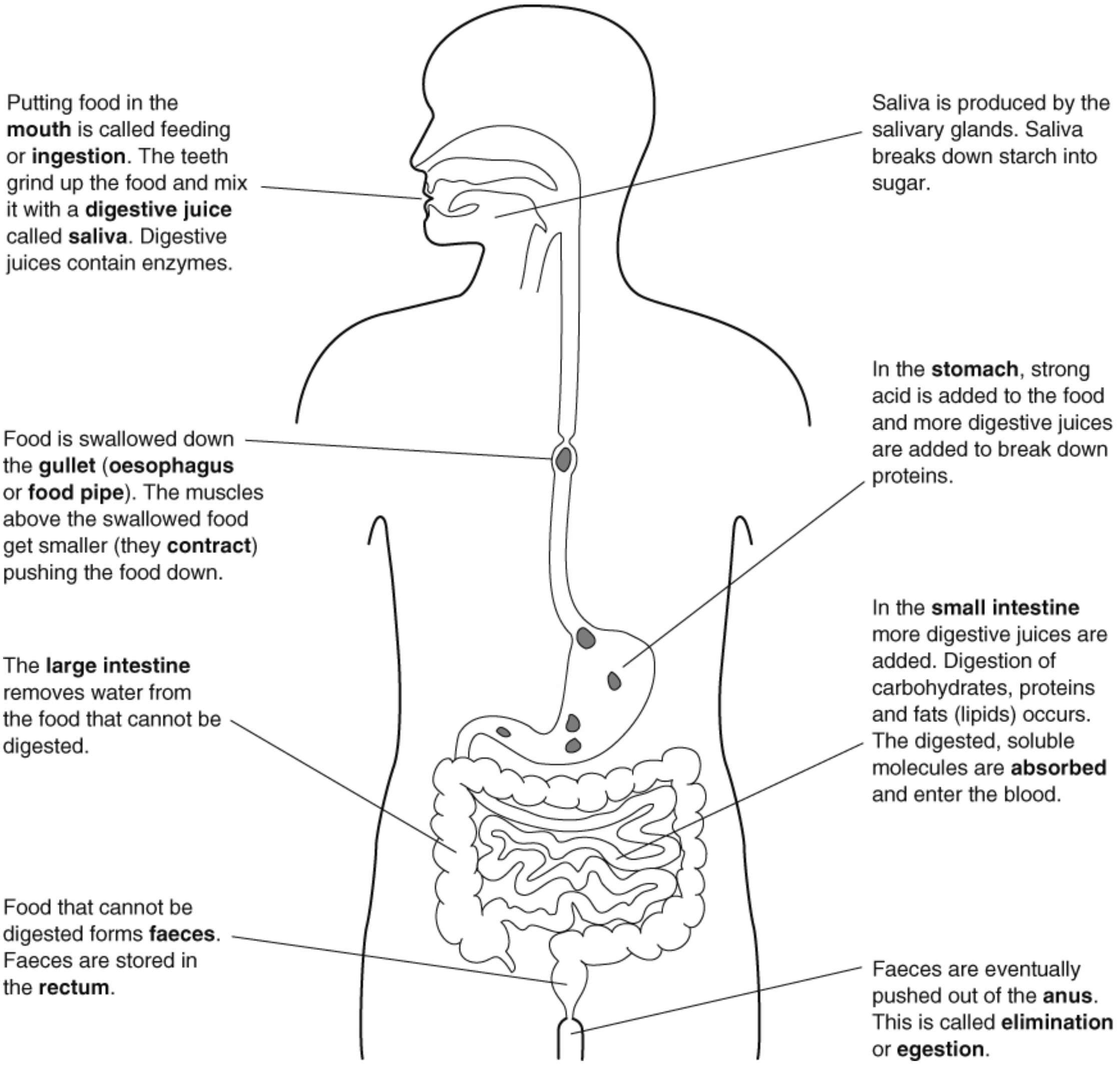
Digestion turns large **insoluble** substances into small **soluble** ones. The organs of the **digestive system** help us digest food. Many of them produce **enzymes** (substances that are **catalysts** and help speed up food digestion).

We can use a **model** to make it easier to think about how enzymes work:



The gut

Food is digested in the **gut**.



Putting food in the **mouth** is called feeding or **ingestion**. The teeth grind up the food and mix it with a **digestive juice** called **saliva**. Digestive juices contain enzymes.

Saliva is produced by the salivary glands. Saliva breaks down starch into sugar.

In the **stomach**, strong acid is added to the food and more digestive juices are added to break down proteins.

Food is swallowed down the **gullet** (**oesophagus** or **food pipe**). The muscles above the swallowed food get smaller (they **contract**) pushing the food down.

In the **small intestine** more digestive juices are added. Digestion of carbohydrates, proteins and fats (lipids) occurs. The digested, soluble molecules are **absorbed** and enter the blood.

The **large intestine** removes water from the food that cannot be digested.

Food that cannot be digested forms **faeces**. Faeces are stored in the **rectum**.

Faeces are eventually pushed out of the **anus**. This is called **elimination** or **egestion**.

To help absorb the digested food, the wall of the small intestine is folded and covered with **villi**. The cells have microvilli. These features all increase the **surface area**. The wall of the small intestine is also only one-cell thick, meaning that it is easy for small molecules to **diffuse** out of the small intestine and into the blood. The digested food molecules are carried in the blood **plasma**.

The surface area is the total area of the faces of a three-dimensional object.

Kingdoms

Organisms are classified into five **kingdoms**. **Viruses** are not living and so are not in a kingdom.

Cell part	**Kingdom**				
	prokaryotes (all unicellular)	**protoctists (mainly unicellular)**	**fungi (mainly multicellular)**	**plants (all multicellular)**	**animals (all multicellular)**
cytoplasm	✓	✓	✓	✓	✓
cell membrane	✓	✓	✓	✓	✓
nucleus	✗	✓	✓	✓	✓
mitochondria	✗	✓	✓	✓	✓
cell wall	✓	✗/✓	✓	✓	✗
chloroplasts	✗	✗/✓	✗	✓	✗

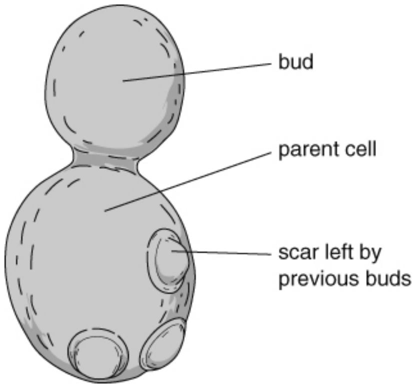
Unicellular organisms can only grow to a certain size. If the organism is too big, it cannot get enough of the substances it needs throughout the cell because diffusion is too slow.

The tissues in multicellular organisms need to have raw materials transported to them because diffusion would be too slow.

Microscopic fungi

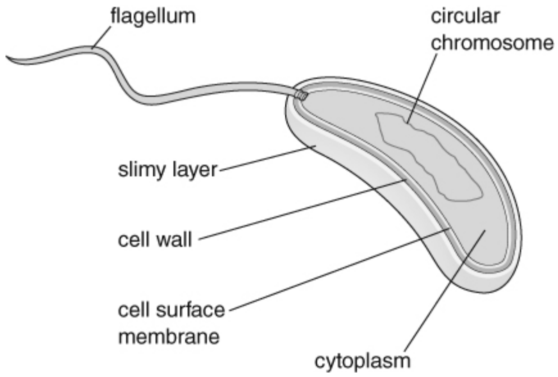
These include, for example, yeast. They:

- reproduce asexually by budding
- can use aerobic respiration, which is important in baking
- can use anaerobic respiration (fermentation), which is important in alcoholic drink manufacture.



glucose → carbon dioxide + ethanol (alcohol)

Bacteria



Parts of a bacterium

Some bacteria are important in making yoghurt and cheese. These bacteria use a type of anaerobic respiration to ferment milk:

glucose → lactic acid

Feeding

Bacteria and fungi feed by releasing **enzymes** into their surroundings to digest large **organic molecules**. The digested molecules are then absorbed.

Protoctists

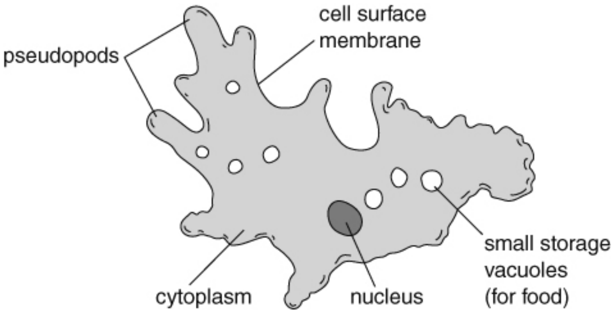
There are many different types of protoctist and some can **photosynthesise**:

carbon dioxide + water → glucose + oxygen

Photosynthesising protoctists are therefore **producers** in a **food chain**, for example:

algae → pond snail → minnow → grey heron
(producer) (**consumer**, **herbivore**) (consumers, **carnivores**, **predators**)

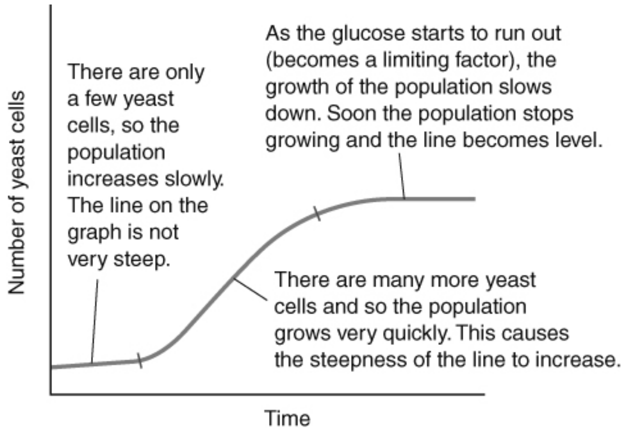
Some protoctists move using **pseudopods**, while others use **cilia** and others use **flagella**.



Parts of an *Amoeba*

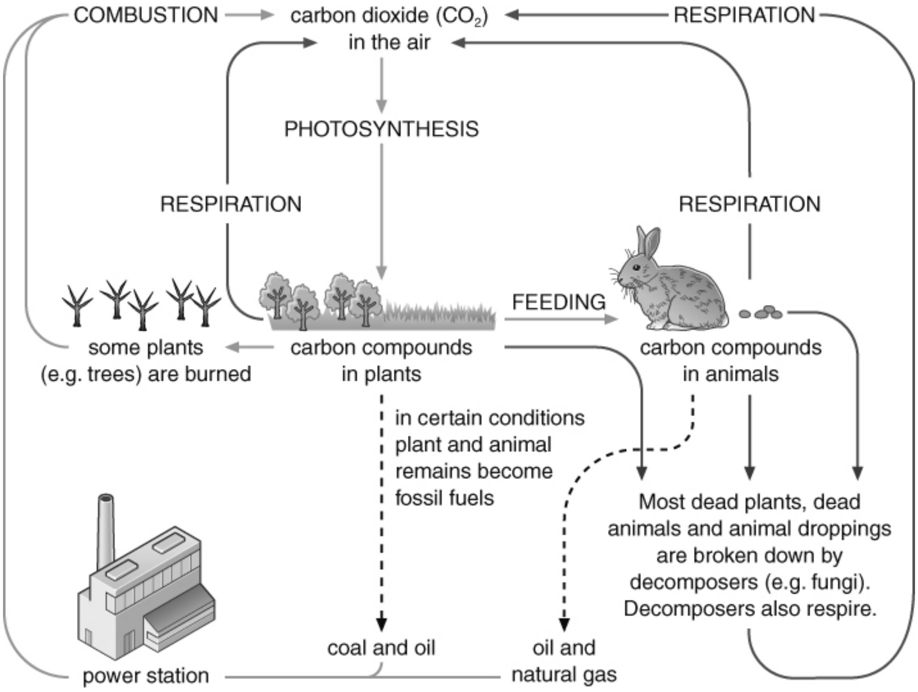
Growth

All microorganisms need warmth, food and moisture to grow well. Some need light for photosynthesis. Some need oxygen for aerobic respiration. The increase in a population can be shown on a growth curve. Something that stops a population from increasing further is called a **limiting factor**.



The carbon cycle

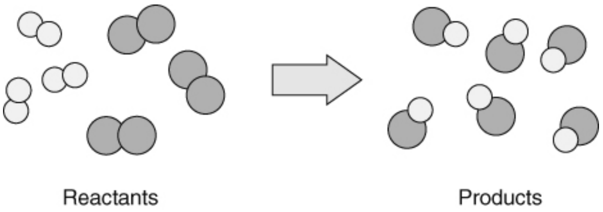
Many unicellular microorganisms are **decomposers** and play an important part in the **carbon cycle**.



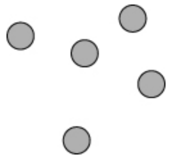
Dalton's atomic theory

Dalton's theory stated that:

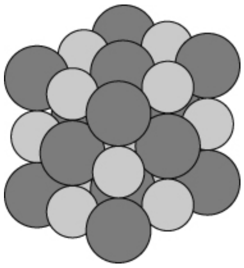
- All matter is made up of tiny particles called atoms.
- Atoms are indestructible, and cannot be created, or destroyed.
- The atoms in an element are all identical.
- In compounds, each atom of an element is always joined to a fixed number of atoms of the other elements.
- During chemical reactions, atoms rearrange, to make new substances. For example:



No atoms are lost or gained so the mass of the reactants is equal to the mass of the products.



Atoms of an element.



Atoms in a compound.

Word equations

The word equation for the above change is:

hydrogen + chlorine → hydrogen chloride
REACTANTS PRODUCTS

Some signs of a chemical reaction include:

- colour change
- gas produced
- solid formed from solution
- energy change.

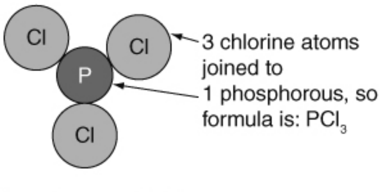
Elements and their symbols

The **symbols** for the elements used today have been agreed by scientists in all countries. They are either a single or double letter. The first letter is always a capital letter.

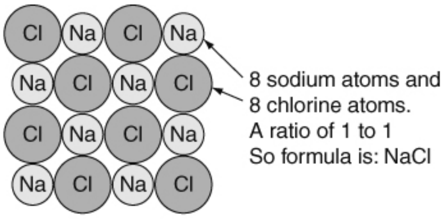
Examples:

nitrogen = **N**
sulfur = **S**
chlorine = **Cl**
lithium = **Li**
copper = **Cu**
iron = **Fe**

Formulae



Phosphorous chloride
PCl_3



Sodium chloride
NaCl

The **chemical formula** of a substance tells you the number of atoms of each element that are joined in its molecules, or the ratio of atoms of each element in the compound.

Metals and non-metals

The common **properties** of most **metals** are:

- high melting points
- solids at room temperature
- strong and **flexible**
- malleable
- shiny (when polished)
- good **conductors of heat and electricity**.

The common properties of most **non-metals** are:

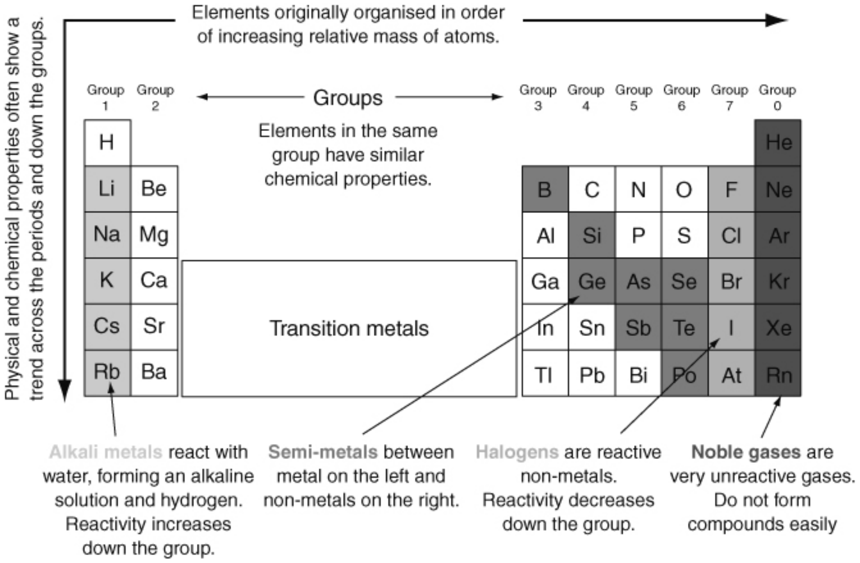
- low melting point
- **brittle**(when solid)
- not shiny
- poor conductors of heat and electricity.

The properties of a substance are what it looks like or what it does. There are two types of properties:

- **chemical properties** (e.g. flammability, pH, reaction with acid)
- **physical properties** (e.g. melting point, boiling point, density).

The periodic table

The **periodic table** arranges the elements so that elements with similar properties are in the same vertical **group**. The periodic table also allows us to spot trends and patterns.



Elements originally organised in order of increasing relative mass of atoms.

Physical and chemical properties often show a trend across the periods and down the groups.

Elements in the same group have similar chemical properties.

Alkali metals react with water, forming an alkaline solution and hydrogen. Reactivity increases down the group.

Semi-metals between metal on the left and non-metals on the right.

Halogens are reactive non-metals. Reactivity decreases down the group.

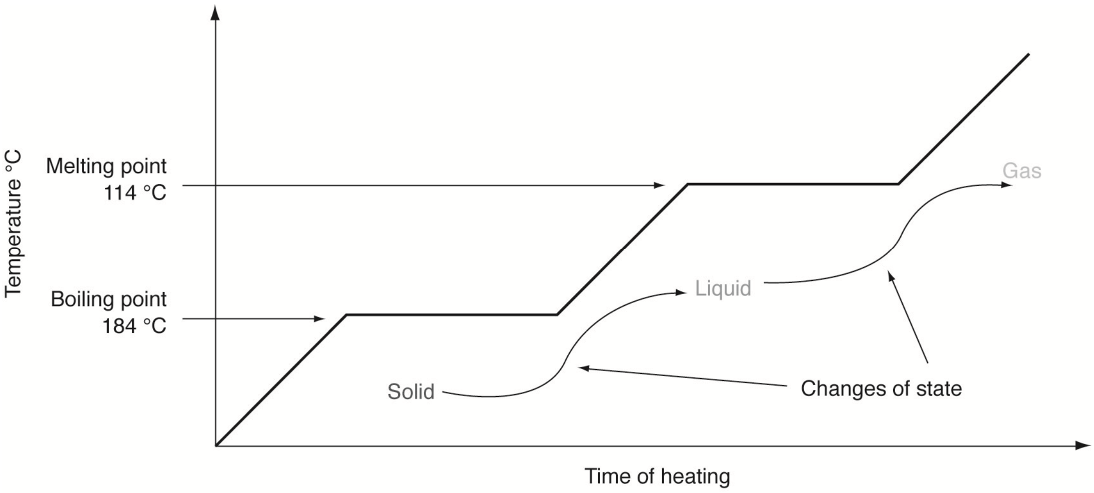
Noble gases are very unreactive gases. Do not form compounds easily

Metal and non-metal oxides

Many elements burn in air/oxygen to form oxides; e.g.:

- calcium + oxygen → calcium oxide
- metal oxides tend to form alkaline solutions.
- carbon + oxygen → carbon dioxide
- non-metal oxides tend to form acidic solutions.

Changes of state

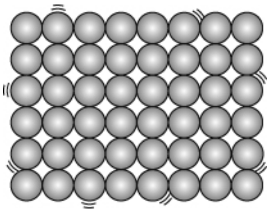
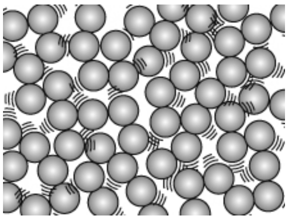
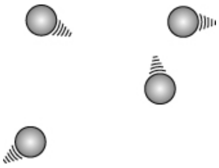


Fluids

Fluids are liquids or gases.

The particle model

The particle model can explain the properties of solids, liquids and gases.

	Solids	Liquids	Gases
Properties	● fixed volume ● fixed shape	● fixed volume ● take shape of container	● expand to fill container ● take shape of container
Particle diagram			
Particles	● are close together ● are held in fixed positions by strong forces	● are close together ● are held by fairly strong forces ● can move around	● are far apart ● are held by very weak forces ● can move around

Density

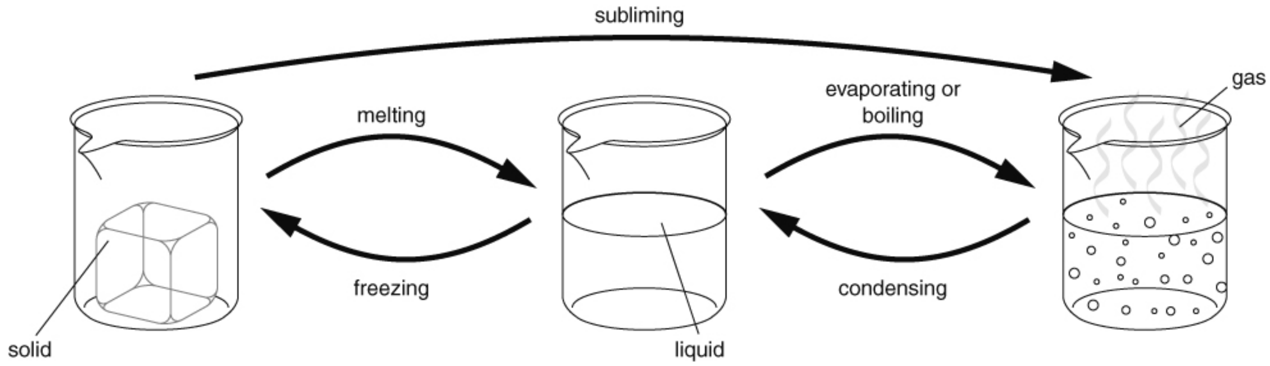
Density is the mass of a certain volume of something, and it can be calculated using this formula:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

The units for density are g/cm^3 or kg/m^3.

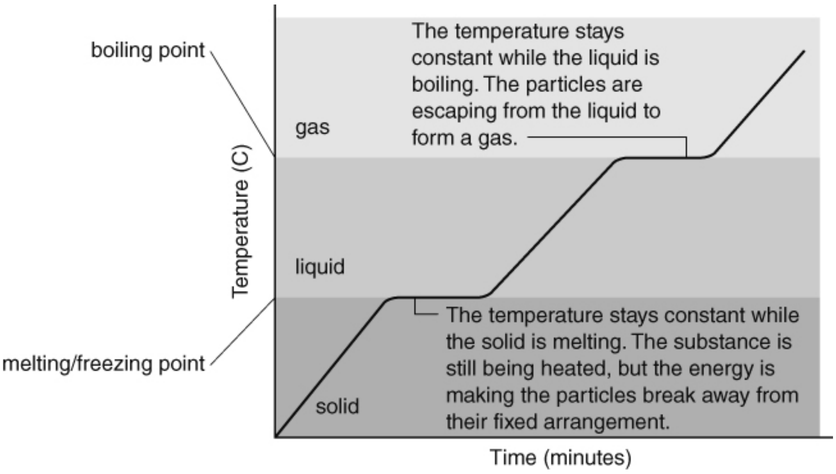
Changes of state

Substances can change state when they are heated or cooled. The three states of matter are solid, liquid and gas.



A liquid evaporates from its surface. When it is boiling, bubbles of gas form within the liquid.

The melting point and the freezing point of a substance are the same temperature. The temperature of a substance does not change while it is melting, even if it is still being heated.



Changing density

Substances expand when they are heated. The particles in a solid vibrate more and take up more space. The particles in liquids and gases move around faster and take up more space. When a material expands its density decreases.

Substances contract when they cool down, as the particles have less energy and do not move as much. This reduces the volume and increases the density. When a liquid freezes and becomes a solid its density increases a lot.

Ice is unusual, because it is *less* dense than liquid water. This is why ice floats on water.

Pressure in fluids

Both gases and liquids are fluids. Fluids can flow. Pressure in fluids acts in all directions. The particles in fluids are moving all the time and hitting the walls of containers and other things they come into contact with. The force of the collisions causes pressure, which acts in all directions.

The pressure of gas in a container can be increased by:

- putting more particles into the container (so there will be more collisions with the container walls each second).
- heating the gas (so the particles move faster, hitting the walls harder and more often).
- reducing the volume of the container (so the particles do not have as far to go between the walls and so collide with the walls more often).

As you go deeper into the sea, pressure increases because there is more water above you pressing down. If you climb a high mountain, the air pressure on you will get less, because there is less air above you pressing down.

Floating and sinking

You can decide if something will float by working out its density, and the density of the fluid. If the density of the object is less than the density of the fluid, it will float.

The density of water is 1 g/cm^3, so objects with densities less than 1 g/cm^3 will float in water.

Drag

Drag is another name for air resistance or water resistance. The amount of drag on something can be reduced by giving it a smooth surface and a streamlined shape. The drag increases as the speed increases, so cars use up more fuel per kilometre when they are travelling fast. Drag is caused by particles in the fluid hitting the moving object, and by the force needed for the object to push the fluid out of the way. The particles transfer energy to the object, which is why objects moving through air can get hot.

Physical changes and chemical reactions

Physical changes	Chemical reactions
Do not make new substances.	Always make one or more new substances.
Are often easy to reverse.	Are usually difficult to reverse.
The substances may change state or just be mixed together.	The new substances have different properties from the original substances.
Examples include: melting, boiling, condensing, freezing.	Examples include: combustion, neutralisation, thermal decomposition.

Gas pressure

Gas pressure is caused by the force of the particles hitting the walls of the container.

Change that increases pressure	Reason
increase the temperature	the particles move faster and so hit the walls of the container with more force and more often
increase the number of particles in the container	the particles are closer together and hit the walls of the container more often
decrease the volume of the container	the particles are closer together and hit the walls of the container more often

The reactivity series

This is a list of metals in order of reactivity, with the most reactive at the top.

The metals that react with water produce a metal hydroxide and hydrogen.

The metals that react with dilute acids produce a salt and hydrogen.

Most metals react with oxygen from the air to form metal oxides. This is an **oxidation** reaction.

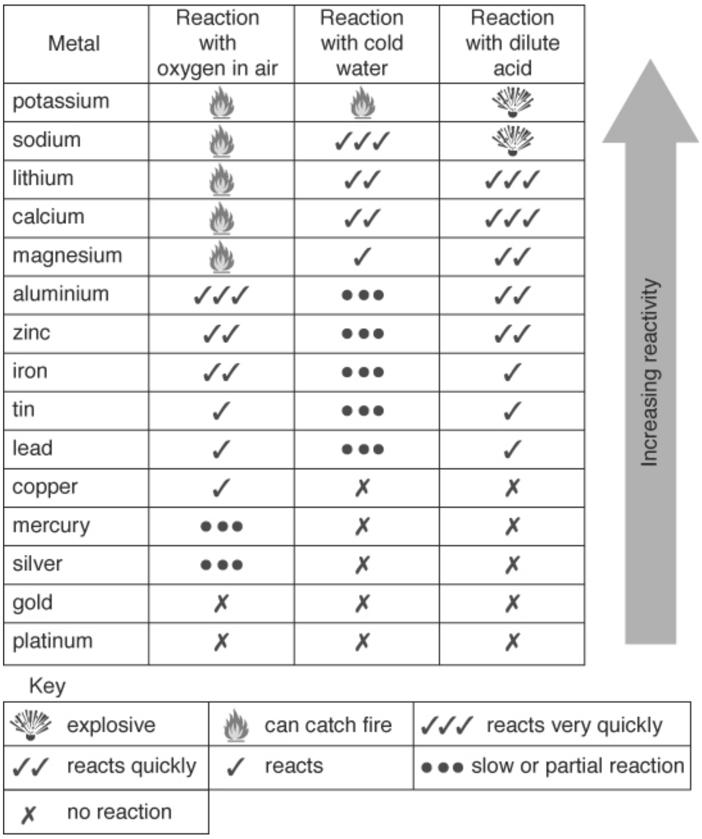
Rusting of iron

Steel is an alloy containing iron mixed with small amounts of carbon and sometimes other metals. Iron and steel need air and water to rust. Salt makes them rust more quickly than usual.

Rusting can be prevented by:

- a physical barrier to stop the air and water being in contact with the iron
- sacrificial protection, in which blocks of a more reactive metal, such as zinc or magnesium, are attached to the iron. They then corrode instead of the iron.

Stainless steel is an alloy of iron containing chromium and it does not rust.



Metal	Reaction with oxygen in air	Reaction with cold water	Reaction with dilute acid
potassium	🔥	🔥	💥
sodium	🔥	✓✓✓	💥
lithium	🔥	✓✓	✓✓✓
calcium	🔥	✓✓	✓✓✓
magnesium	🔥	✓	✓✓
aluminium	✓✓✓	●●●	✓✓
zinc	✓✓	●●●	✓✓
iron	✓✓	●●●	✓
tin	✓	●●●	✓
lead	✓	●●●	✓
copper	✓	✗	✗
mercury	●●●	✗	✗
silver	●●●	✗	✗
gold	✗	✗	✗
platinum	✗	✗	✗

Key

💥 explosive	🔥 can catch fire	✓✓✓ reacts very quickly
✓✓ reacts quickly	✓ reacts	●●● slow or partial reaction
✗ no reaction		

Hydrocarbons

These substances contain hydrogen and carbon only. They burn in a plentiful supply of air to form carbon dioxide and water:

hydrocarbon + oxygen → carbon dioxide + water

The test for oxygen is that it relights a glowing splint.

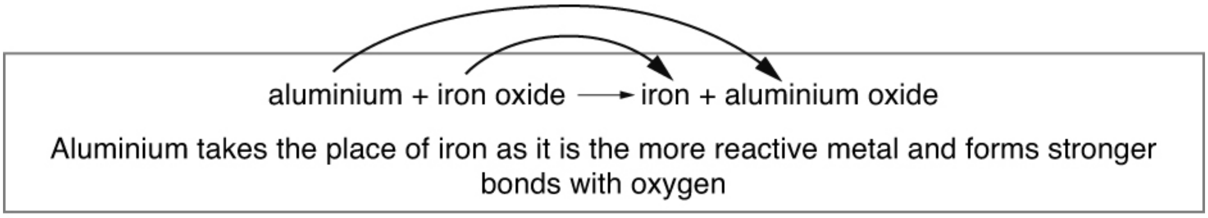
An input of energy from a flame or spark is needed to start the combustion reaction by breaking some bonds in the reactants. Explosive mixtures contain an **oxidising agent** to provide extra oxygen for the reaction.

Energy changes

- Exothermic reactions transfer energy from the reactants to the surroundings. The temperature of the surroundings increases.
- Endothermic reactions use energy transferred from the surroundings to the reactants. The temperature of the surroundings decreases.

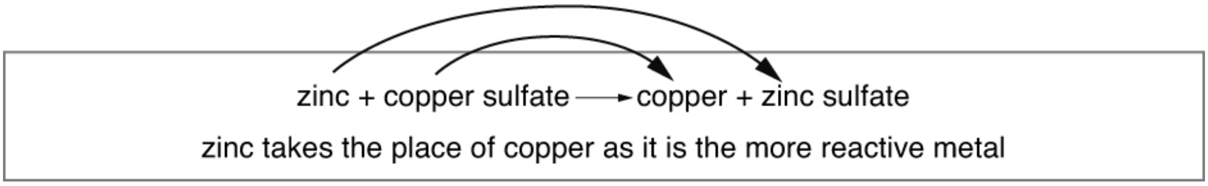
Displacement reactions

In a **displacement reaction** a more reactive metal takes the place of a less reactive metal in a compound.



aluminium + iron oxide → iron + aluminium oxide

Aluminium takes the place of iron as it is the more reactive metal and forms stronger bonds with oxygen



zinc + copper sulfate → copper + zinc sulfate

zinc takes the place of copper as it is the more reactive metal

Extracting metals

- Most metals occur as compounds in ores in the Earth's crust. Only a few, such as silver and gold, occur as the metallic element.
- The metals high in the reactivity series are difficult to chemically extract from their ores and their isolation has happened relatively recently.
- The metals lower in the reactivity series are easier to extract from their ores and they have been available to use as the pure elements for much longer.
- Metals from zinc downwards in the reactivity series can be extracted from their ores by heating with carbon.
- Metals above zinc in the reactivity series need electrolysis to extract them from their ores.
- Oxidation is the gain of oxygen. **Reduction** is the loss of oxygen.

Percentage loss or gain

This is the $\frac{\text{actual change}}{\text{original amount}} \times 100$