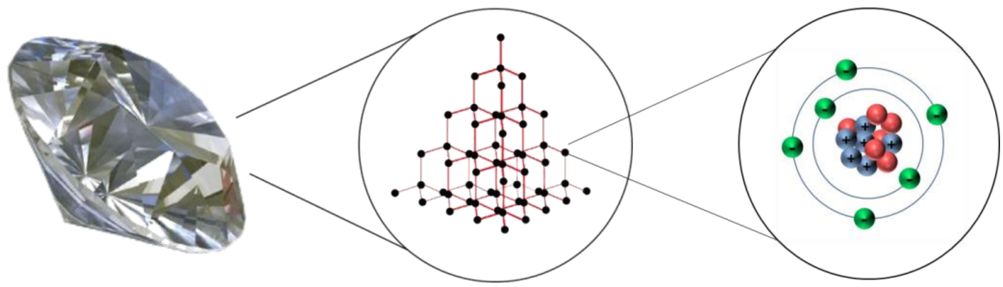
All Matter is made up of particles

Matter exists in different types as elements, compounds or mixtures.

Particles make up all matter in the Universe. The three particles that make up these types of matter are atoms, molecules and ions.

Different types of matter can have different types of particles. The type of particles and the way these are arranged and connected to each other determines the type of matter, and therefore the physical and chemical properties of the matter.



Matter can exist in different arrangements (configurations)

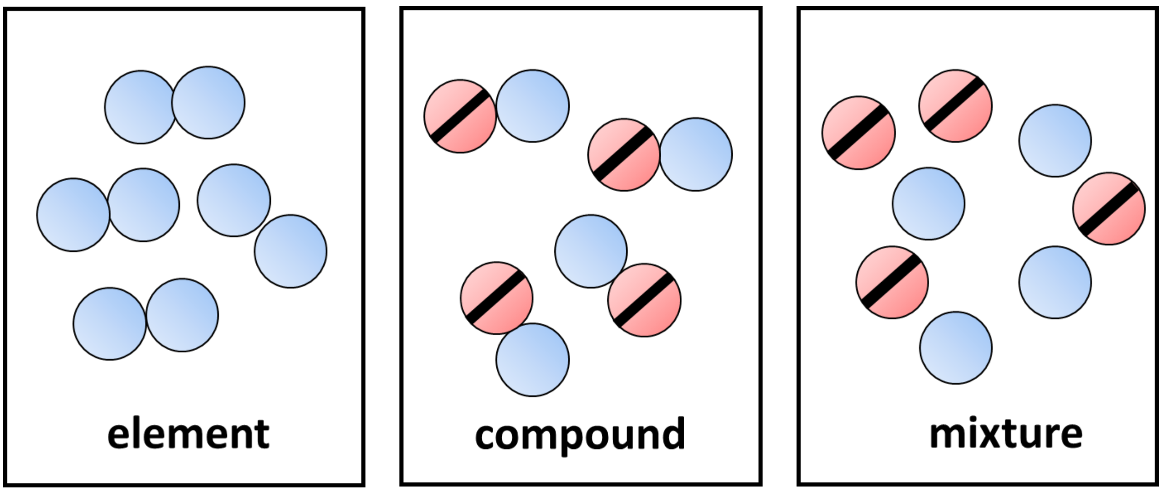
Elements are substances made up of only one type of atom/particle (in the same space), and can be a solid, liquid or gas. There are approximately 130 different elements but many millions of substances. Most matter around us is made up of combinations of elements.

If two or more different elements have chemically reacted together and joined then they form a compound.

If different elements and/or compounds are in the same physical space and not chemically joined then they form a mixture.

Particle diagrams

Different types of matter can be drawn using particle diagrams. Each different colour represents a different type of particle. Elements only have one type of particle. Compounds have more than one type of particle joined together. Mixtures have more than one type of particle but they are not joined and can be separated physically.



Everyday examples of Elements, Compounds and Mixtures

All around us are examples of elements, compounds and mixtures. Few pure elements are found in nature because they react with chemicals around them so instead we have chemical processes to extract and purify them.

Many of the everyday items that we use are compounds that have been manufactured by chemical processes as well. We find mixtures in nature, such as iron sand, that we can separate by physical processes. We can also create mixtures to use.

Elements are everywhere

Over 130 Elements make up all of the matter in the universe but only about 20 types are commonly found on Earth. Each type of element has a unique type of atom/particle (being the only one of its kind). The Earth, as well as all living things on it, is made up of a combination of the elements in different forms.

Many of the common types of elements are grouped in the first 20 elements out of 130+ elements. These elements can either be gas, liquid or solid at room temperature.

These pictures show the elements in pure form but most elements are found in their ion form joined together with other ions into compounds, such as sodium with chloride (chlorine) and calcium with oxygen and carbon

Other important elements

Other elements that are common can be found further down the list of elements – many of these tend to be metals.

Gold	Iron	Copper	Silver
			
Lead	**Bromine**	**Iodine**	**Zinc**
			

Each element is named and has its own symbol.

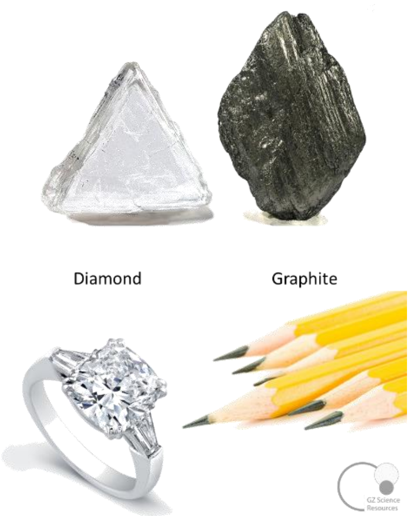
Elements consist of only one type of atom. (particle) Each element can be represented by a chemical symbol, which is made up of one or two letters.

The element symbols are one or two letters, formed from the name of the element. Such as Hydrogen H, or Helium He. The first letter of the symbol is always a capital letter. Any other letters are lower case. E.g. Helium is He (not HE or he)

If the symbols are not based on an element's English name then it is most likely to be based on its Latin name, the original language of Science.

Name	Symbol	Name	Symbol	Name	Symbol	Name	Symbol
hydrogen	**H**	oxygen	**O**	phosphorus	**P**	silver	**Ag**
helium	**He**	fluorine	**F**	sulfur	**S**	lead	**Pb**
lithium	**Li**	neon	**Ne**	chlorine	**Cl**	zinc	**Zn**
beryllium	**Be**	sodium	**Na**	argon	**Ar**	copper	**Cu**
boron	**B**	magnesium	**Mg**	potassium	**K**	bromine	**Br**
carbon	**C**	aluminium	**Al**	calcium	**Ca**	iodine	**I**
nitrogen	**N**	silicon	**Si**	gold	**Au**	iron	**Fe**

Elements are everywhere - Carbon



Carbon is one of the most important elements for living organisms and it also is present in a large number of non-living substances as well including fuels, types of rocks and as part of carbon dioxide in the air.

There is a fixed amount of carbon on Earth and it gets recycled from living organisms when they die by decomposers and added to the atmosphere as carbon dioxide when they respire.

Some substances are pure carbon such as diamonds, coal and graphite.

Elements are everywhere - Oxygen

Oxygen is essential for living organisms and is required to break down the food into energy during respiration. Pure oxygen is found as a gas on Earth.

Most of our oxygen in our atmosphere came from organisms, bacteria at first then plankton and plants, which broke apart water and released the oxygen during photosynthesis.

Oxygen is a very reactive gas and causes many metals to corrode and rust, chemically combining with the metal to form a compound.

Elements are everywhere - Hydrogen

Hydrogen is the most common element in the universe and is the main component (ingredient) in stars, including our Sun. Nuclear reactions inside the Sun and stars change the hydrogen into helium, another common element, and release large amounts of energy. Life on Earth is dependent on this energy source and planets too far away, are too cold for living organisms to survive.

Hydrogen was also used for bombs that were far more destructive than traditional chemical weapons.

Elements are everywhere - Silicon

Silicon is a similar element to carbon and is one of the most common elements on Earth. In combination with other elements it forms most of the rocks present both above ground and below ground as molten magma (liquid rock).

Sand is made from a combination of silicon and oxygen and when heated it can turn into glass.

Silicon is also very important in computer parts.

Periodic table

Dmitri Mendeleev was a Chemist who created a periodic table and placed the elements in groups based on the element's similar properties. Not all of the elements had been discovered at the time he created the table so he left gaps that have now mostly been filled.

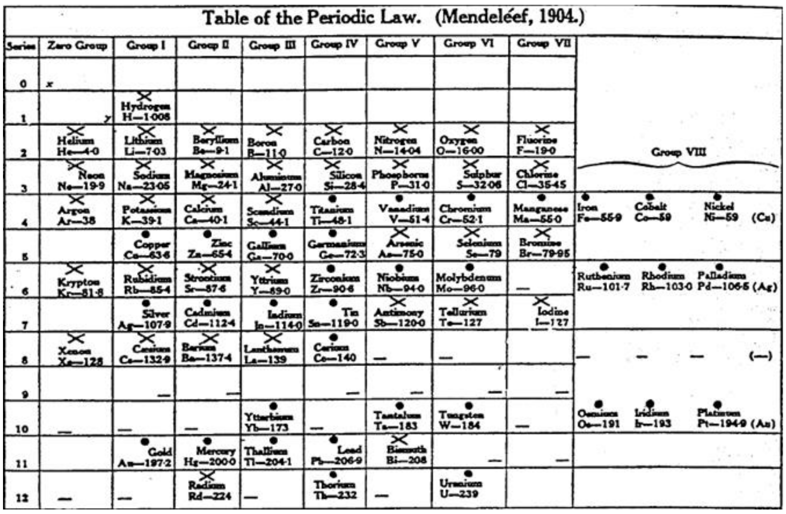
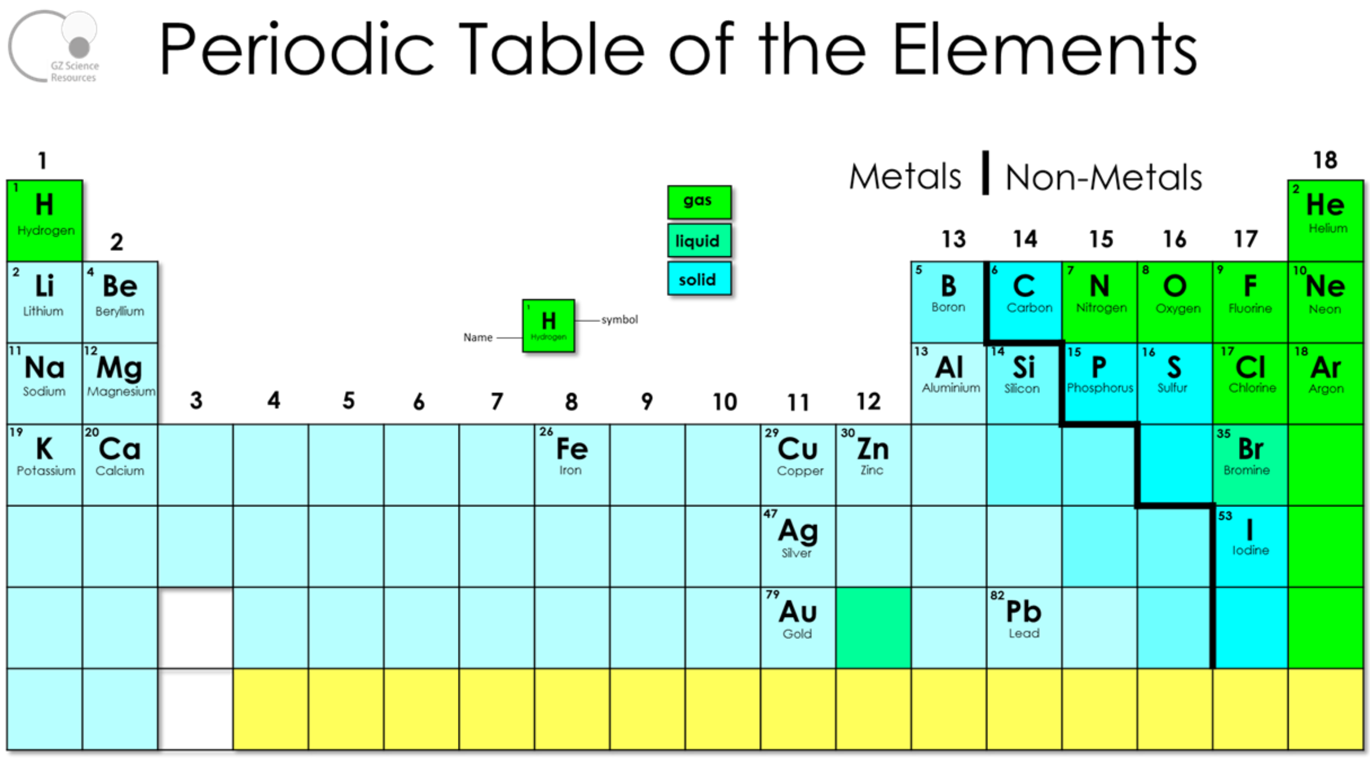


Table of the Periodic Law. (Mendeléef, 1904.)

Series	Zero Group	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
0	x								
1	y	Hydrogen H—1·008							
2	Helium He—4·0	Lithium Li—7·03	Beryllium Be—9·1	Boron B—11·0	Carbon C—12·0	Nitrogen N—14·04	Oxygen O—16·00	Fluorine F—19·0	
3	Neon Ne—19·9	Sodium Na—23·05	Magnesium Mg—24·1	Aluminium Al—27·0	Silicon Si—28·4	Phosphorus P—31·0	Sulphur S—32·06	Chlorine Cl—35·45	
4	Argon Ar—38	Potassium K—39·1	Calcium Ca—40·1	Scandium Sc—44·1	Titanium Ti—48·1	Vanadium V—51·4	Chromium Cr—52·1	Manganese Mn—55·0	Iron Fe—55·9 Cobalt Co—59 Nickel Ni—59 (Cu)
5		Copper Cu—63·6	Zinc Zn—65·4	Gallium Ga—70·0	Germanium Ge—72·3	Arsenic As—75·0	Selenium Se—79	Bromine Br—79·95	
6	Krypton Kr—81·8	Rubidium Rb—85·4	Strontium Sr—87·6	Yttrium Y—89·0	Zirconium Zr—90·6	Niobium Nb—94·0	Molybdenum Mo—96·0	—	Ruthenium Ru—101·7 Rhodium Rh—103·0 Palladium Pd—106·5 (Ag)
7		Silver Ag—107·9	Cadmium Cd—112·4	Indium In—114·0	Tin Sn—119·0	Antimony Sb—120·0	Tellurium Te—127	Iodine I—127	
8	Xenon Xe—128	Cæsium Cs—132·9	Barium Ba—137·4	Lanthanum La—139	Cerium Ce—140	—	—		— — — (—)
9		—	—		—	—	—	—	
10	—	—	—	Ytterbium Yb—173	—	Tantalum Ta—183	Tungsten W—184	—	Osmium Os—191 Iridium Ir—193 Platinum Pt—194·9 (Au)
11		Gold Au—197·2	Mercury Hg—200·0	Thallium Tl—204·1	Lead Pb—206·9	Bismuth Bi—208	—	—	
12	—	—	Radium Rd—224	—	Thorium Th—232	—	Uranium U—239		

Metals and non-metals can be identified from their position on the periodic table

Elements can be classified as metals or non-metals. Metals are placed on the left hand side and non-metals are placed on the right hand side of the periodic table. Nearly 2/3 of all elements are metals.

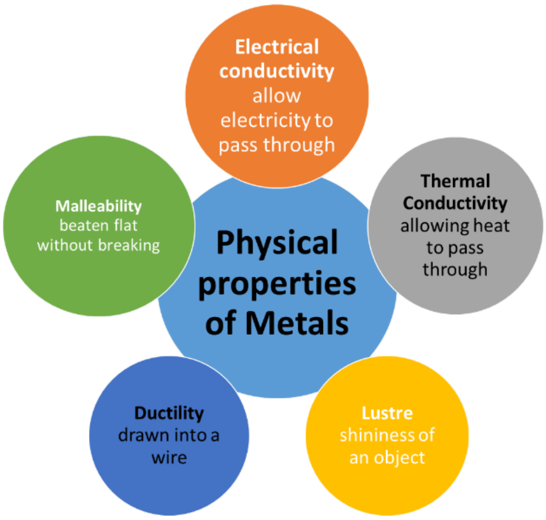


Metals

Metals can be distinguished from non-metals by their physical properties; they are strong, dense, shiny solids that can be worked into different shapes. They are good conductors of heat and electricity.

The Physical Properties of Metals

Many of these physical properties are unique to metals and because of that, metals are used for many situations that other non-metals could not be used.



Metal physical properties

Copper • Reddish-brown in colour • Malleable • Ductile • Good heat and electrical conductivity •Electrical wires •Heating pipes •Roofing 	Iron •Ductile, malleable & tough. •Shrinks on cooling •Making water pipes, gas pipes and sewers •Making ornamental castings such as brackets, gates, lamp posts, spiral staircases etc. •Making parts of machinery. •Can be used to form temporary magnets. •Used where a tough material is required. 
Lead •Can be cut with a knife. •Lustrous (shiny) & heavy metal •Bluish-grey colour •Very soft & plastic (malleable) at room temperature •Toilet fittings, water-proof and acid proof chambers •Gas pipes, roof gutters •Damp-proof courses of buildings, cable coverings •Plates for storage batteries, covering for electrical cables 	Aluminium •Silver in colour •Very strong but light in weight •Very good conductor of heat and electricity •Non-magnetic substance •Soft & malleable •Ductile •Making automobile bodies, engine parts •Conductive of heat and electricity • Manufacture of electrical conductors •Making drink cans, high tension wires 

Metal physical properties – Gold

•Yellow gold in colour •Very soft and malleable and heavy in weight •Very good conductor of heat and electricity •Ductile •Jewellery and decorative objects •Manufacture of audio wires and fittings •Gold bullion (bars) and coins

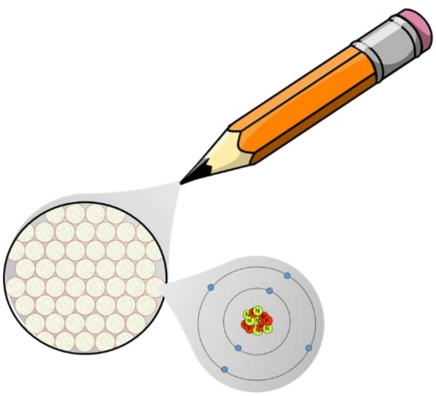
Metal uses Summary

We select appropriate metals, which are the most useful for the task or technology they assist with, because of their particular physical properties.

Metal	*Uses*	*Property involved*
copper	Pipes. Wires. cooking pots	Excellent electrical conductor Good thermal (heat) conductor
aluminium	Aircraft frames wires	Strong and light Good conductor and ductile
Gold (and silver)	Jewellery	Colour, malleable and ductile
lead	Roof flashing	Very malleable
iron	Car bodies Structural steel	Malleable Good heat conductor

Understand that matter is made up of particles /atoms

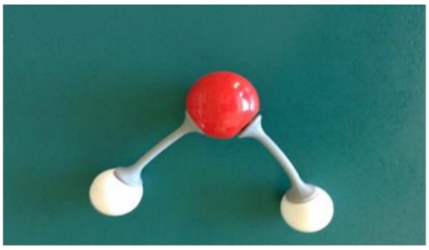
Matter (elements, mixtures and compounds) is made up of particles. The smallest neutral particle that matter can be broken down to is called an atom. Other particles that matter can be made of are molecules and ions. The type of particle and the way these particles are arranged and joined to each other makes different types of matter. Each different type of matter has different physical and chemical properties. These properties mean we use different types of matter for different uses.



Molecules are made from Atoms

When two or more particles join, they form a molecule. The particles can be either the same type of particle (atoms) such as oxygen gas or different types of particles (atoms) such as water.

Oxygen Molecule

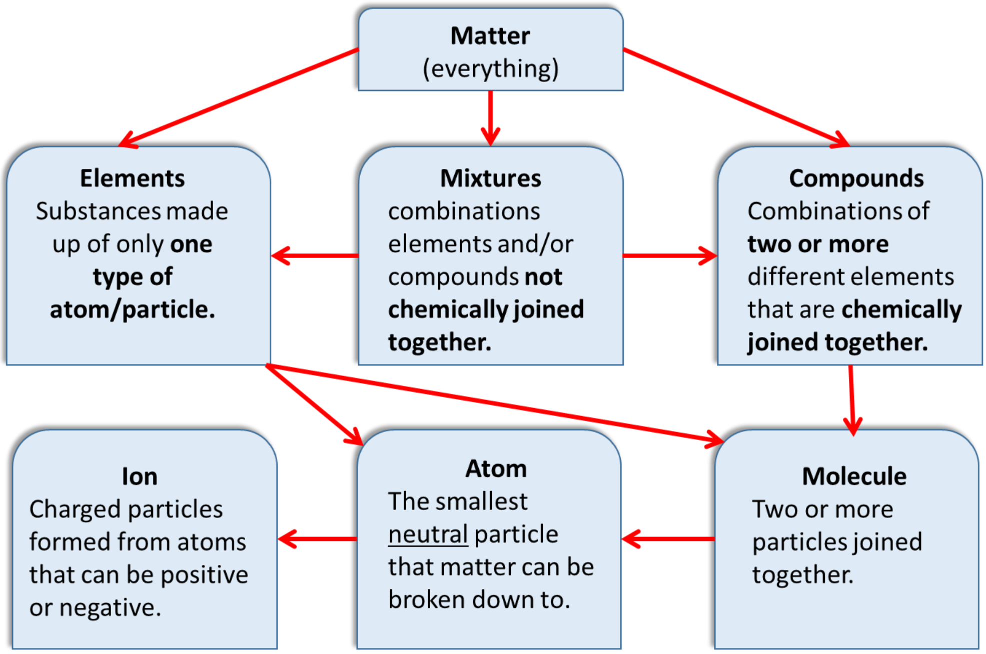


Water Molecule

A molecule of an **element** (such as oxygen gas – made from 2 oxygen atoms) O_2

A molecule of a **compound** (such as water - made from 2 hydrogen and one oxygen atoms). H_2O

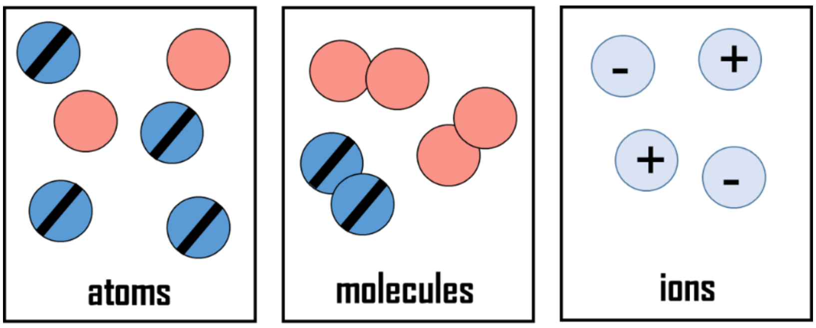
Matter can exist in different arrangements



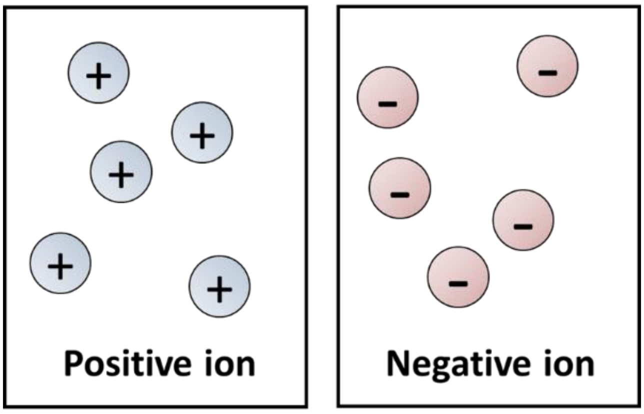
Particle diagrams

Matter is made up of three main types of particles. They are the atom: the smallest <u>neutral</u> particle that matter can be broken down to, the molecule: two or more particles joined together and an ion: charged particles formed from atoms that can be positive or negative.

Different types of particles can be drawn using particle diagrams. Each circle represents an individual particle.

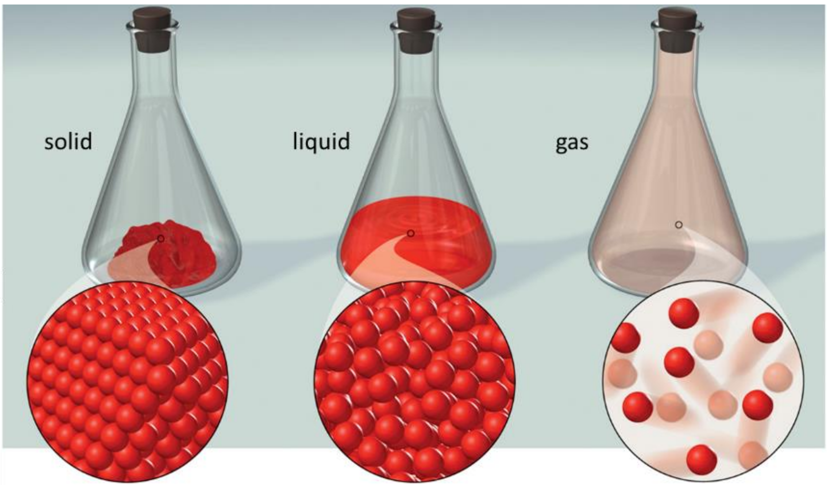


Ions are charged particles



Atoms can sometimes react chemically to form ions. Ions have either a negative charge (from non-metal atoms) or ions that have a positive charge (from metal atoms)

Ions are particles that are often more stable than atoms are.



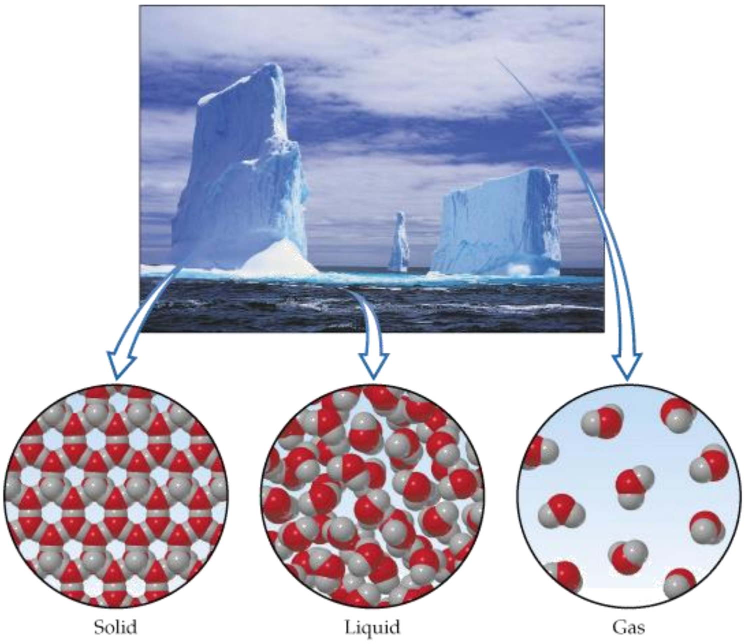
Matter exists in different states – solid, liquid and gases

All matter can be found as either a solid, liquid or gas depending upon the temperature. Each type of matter has its own specific temperature ranges that it will exist in each of these three states. Gases, liquids and solids can be made up of atoms, molecules, and/or ions.

Water as a solid, liquid and gas

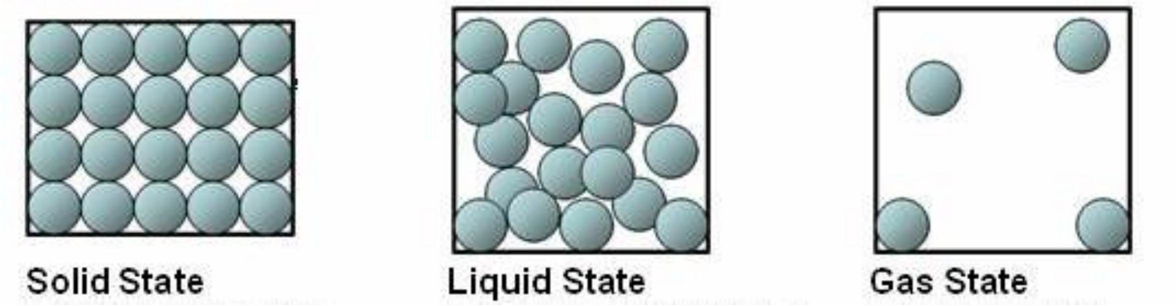
Water is a compound but a very unusual one, because it can be found on Earth naturally as a solid, liquid and a gas.

In solid state, it forms the ice at the poles and covers land in winter and high mountains. In a liquid state it fills our oceans and lakes, as well as creates ground water stored for thousands of years. As a gas, water is found in our atmosphere, the amount is known as the air humidity.



Models for particle arrangement for solid, liquid and gases

Solid particles are packed closely and only vibrate in a fixed position (low energy).
Liquid particles are also packed closely but the particles move around more (more energy than solid particles).
Gas particles have a lot of space between them and move around quickly (particles contain a large amount of energy).



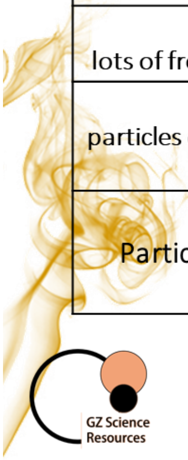
Particles of different states have different strength forces holding them together

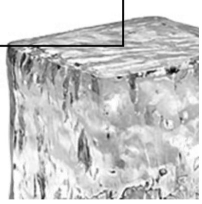
The strength of the forces holding the particles together in matter decreases from solid to liquid to gas. Forces are the strongest between particles in solids where they are held close together. Forces are slightly less with particles in liquids. The particles can move past each other but still are close. Forces are weak between particles in a gas and they move freely away from each other.

Note: strength of forces vary depending on the type of matter but forces still decrease from solid to liquid to gas

Particles are arranged and move differently in solids, liquids and gases

Properties of Gases, Liquids and Solids		
gas	liquid	solid
takes the shape and volume of its container particles can move past one another	takes the shape of the part of the container which it occupies particles can move/slide past one another	retains a fixed volume and shape rigid - particles locked into place
Spreads to fill container particles have weak bonding so they spread by moving rapidly apart from each other	Does not spread to fill a container **particles remain bonded to each other closely and only move past each other but do not spread**	Does not spread to fill a container particles are bonded to each other closely and stay fixed in place so do not spread
compressible lots of free space between particles	not easily compressible little free space between particles	not easily compressible little free space between particles
flows easily particles can move past one another	flows easily particles can move/slide past one another	does not flow easily rigid - particles cannot move/slide past one another
Not dense Particles have large spaces between them	Dense Particles move past each other but still remain close	Dense Particles are closely packed to each other



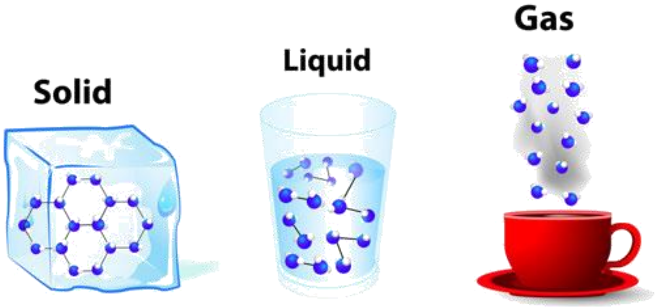


GZ Science Resources

The properties of different states - spreading

All particles to move.

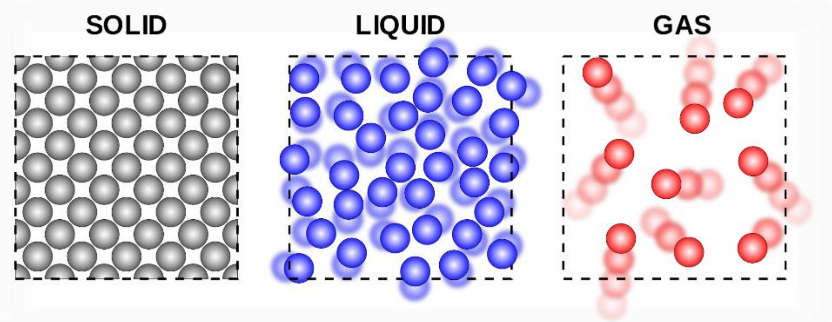
- Gas particles move more than liquid and solid particles so they spread out from each other to completely fill a container. (the volume of gas does increase)
- Liquid particles move past each other and spread to fill a container from the bottom up. (the volume of liquid does not increase)
- Solid particles do not move apart from each other so do not spread to fill a container.



The properties of different states - compressibility

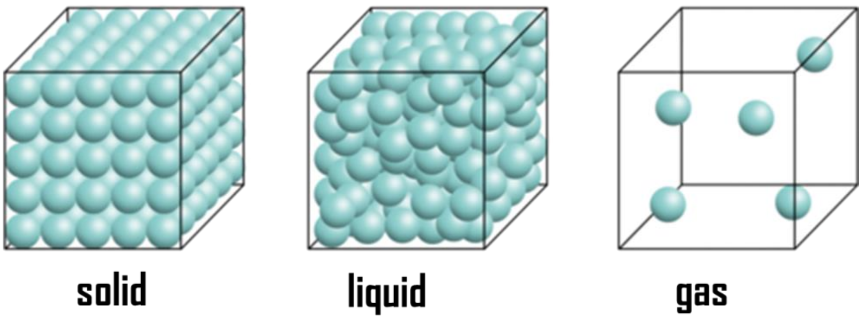
To compress means to push particles closer together and makes the overall volume smaller that the matter takes up.

- Particles in a solid are very close together and cannot be compressed.
- Particles in a liquid, although being able to move past each other, are also very close so cannot be compressed.
- Particles in a gas have large spaces between them so can be compressed.



The properties of different states – density

Density is a measure of the number of particles per unit volume. If a substance has more particles in the same volume than another, it is said to be denser. A substance that is in a solid and liquid state is denser than when it is in a gas state. Note: different substances have different densities but the general pattern is that the density decreases from solid/liquid to gas



The properties of different states – flow / fluidity (Extension)

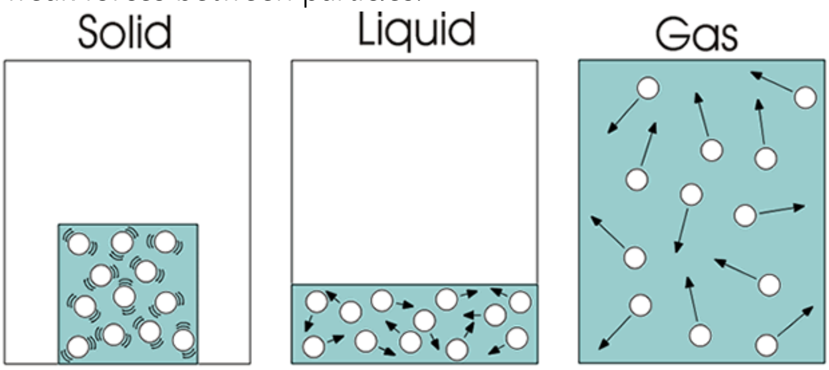
To flow means particles move steadily and continuously in a current or stream

- Particles in a solid do not move past each other and cannot flow.
- Particles in a liquid, can move past each other, while also staying joined so they can flow.
- Particles in a gas also move past each other and some gases like carbon dioxide and nitrogen can flow before particles spread out from each other.

The properties of different states – shape

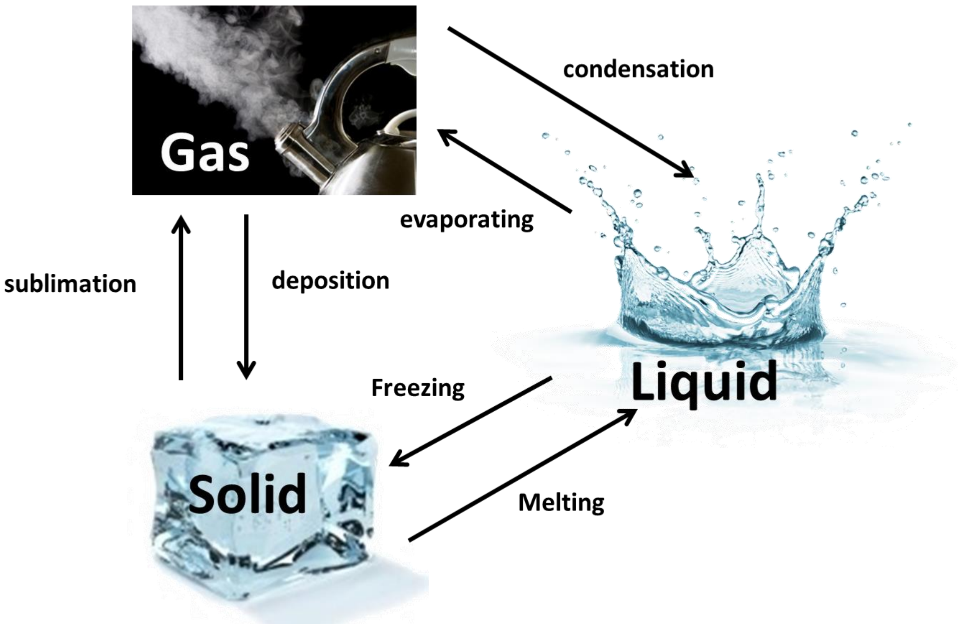
The shape of a substance is linked to its state and the strength of the forces between particles

- Solids remain in a fixed shape – the particles vibrate (shake in one spot) but remain tightly joined to each other with strong forces holding them together.
- Liquids take the shape of the container – the particles can move past each other but are still joined, just with forces that are weaker.
- Gases fill any container they are in – the particles move fast and are not joined to each other due to the very weak forces between particles.



Matter can change from one state to another

If energy is absorbed or released by the particles, which make up the matter, it can change state. A change of state is a physical reaction and it is reversible.



Putting it all together – Change of state

Solid to liquid – melting

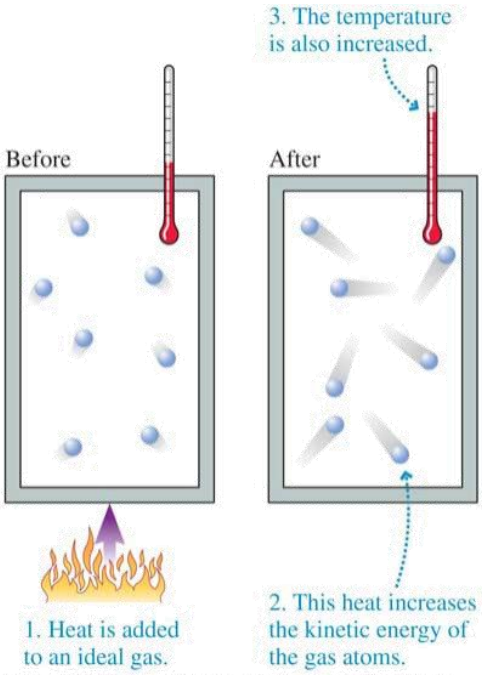
Particles of substances vibrate (move on the spot) faster as they change in state from solid to liquid. This means that the bonds between the particles begins to get weaker. At the point when the particles change from a solid to a liquid, called melting point, the forces holding the particles together is partly overcome and the particles start to slide past each other.

Liquid to gas – boiling

Particles of substances move around even faster as they change in state from liquid to gas. This means that the bonds between the particles get even more weaker. At the point when the particles go from a liquid to a gas, called boiling point, the forces holding the particles together is completely overcome and the particles move away from each other freely.

Temperature is a measure of the movement in particles. (Extension)

The particles in a gas are in constant motion. Temperature is a measure of the speed with which they move. The higher the temperature, the faster the particles move.

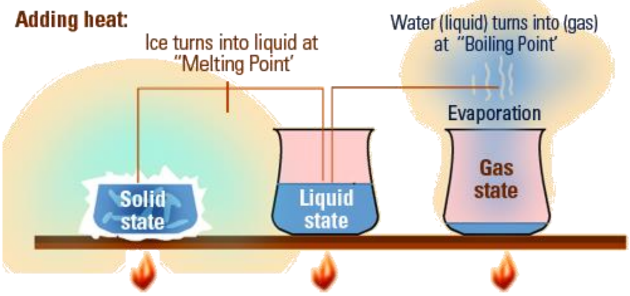


Melting and boiling points

The temperature at which a substance changes from a solid into a liquid is called its melting point. The temperature at which a substance changes from a liquid into a gas is called its boiling point.

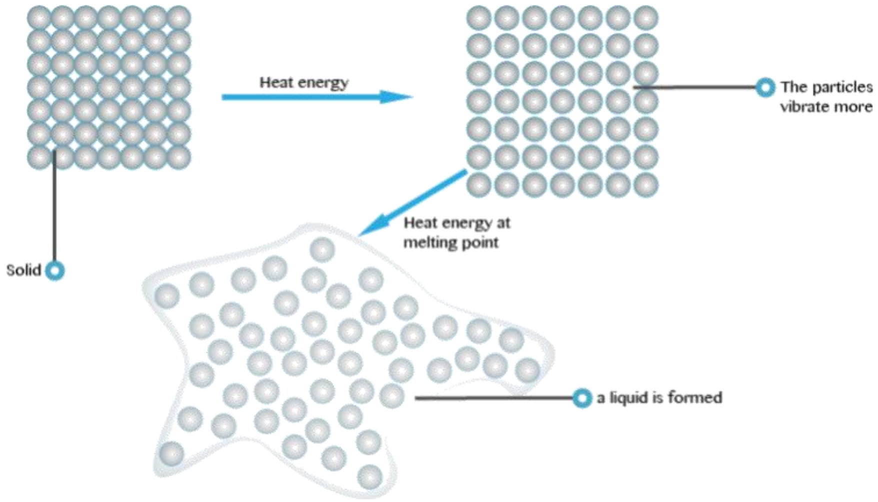
Different types of substances have different melting and boiling points – these are determined by how strong the bonds are between particles or molecules.

(When a molecule melts or boils it is the bonds between the molecules that break not the bonds inside a molecule holding the atoms together)



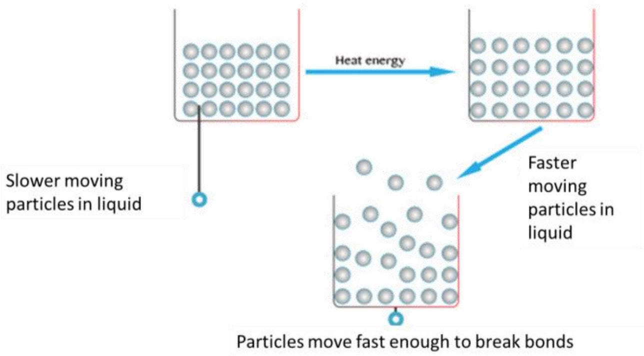
Melting points of water

The melting point of water is 0˚C. This is the temperature where the water molecules have enough movement to overcome the forces holding particles in a fixed position of a solid state and the particles start sliding past each other in a liquid state.



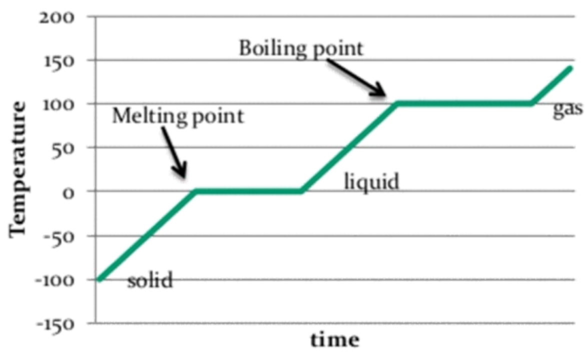
Boiling point of water

The boiling point of water is 100˚C. This is the temperature where the water molecules have enough movement to completely overcome the forces holding particles together and they break away from each other and form a gas.



Melting and boiling points of water - graph

The melting point and boiling point are just average temperatures when a change of state occurs. For example, some water particles will change from liquid to gas at much lower temperatures than 100˚C, such as water evapourating off a road after rain.



Melting and boiling points of water

Melting and boiling point of other substances

The boiling point and melting point of a substance depends upon the strength of the force holding the particles together. If it is a strong force then the boiling and melting points are high. If it is a low force then the melting and boiling points are much lower.

Each type of substance has its own particular melting and boiling point.

Element	M.P. ^{0}C	B.P. ^{0}C	At Room temp
Copper	1,083	2,567	Solid
Magnesium	650	1107	Solid
Oxygen	-218.4	-183	Gas
Carbon	3,500	4827	Solid
Helium	-272	-268.6	Gas
Sulphur	112.8	444.6	Solid
Mercury	-38.87	356.5	Liquid

Chemical and Physical change

Physical changes do not produce a new substance. Changes in state (melting, freezing, vaporization, condensation, sublimation) are physical changes. Examples of physical changes also include bending a piece of wire, melting icebergs, and breaking a bottle

A chemical change occurs when a new substance is formed and is not easily reversible. Observations to show a chemical change could be a colour change, a new smell, the chemicals get hotter or colder or a gas is produced.

Evidence for Chemical and Physical change

Evidence of Chemical Changes

- ❑ Burning wood – temperature change
- ❑ Mixing acid with universal indicator – colour change
- ❑ Seeing bubbles when vinegar and baking soda are mixed – a gas is formed

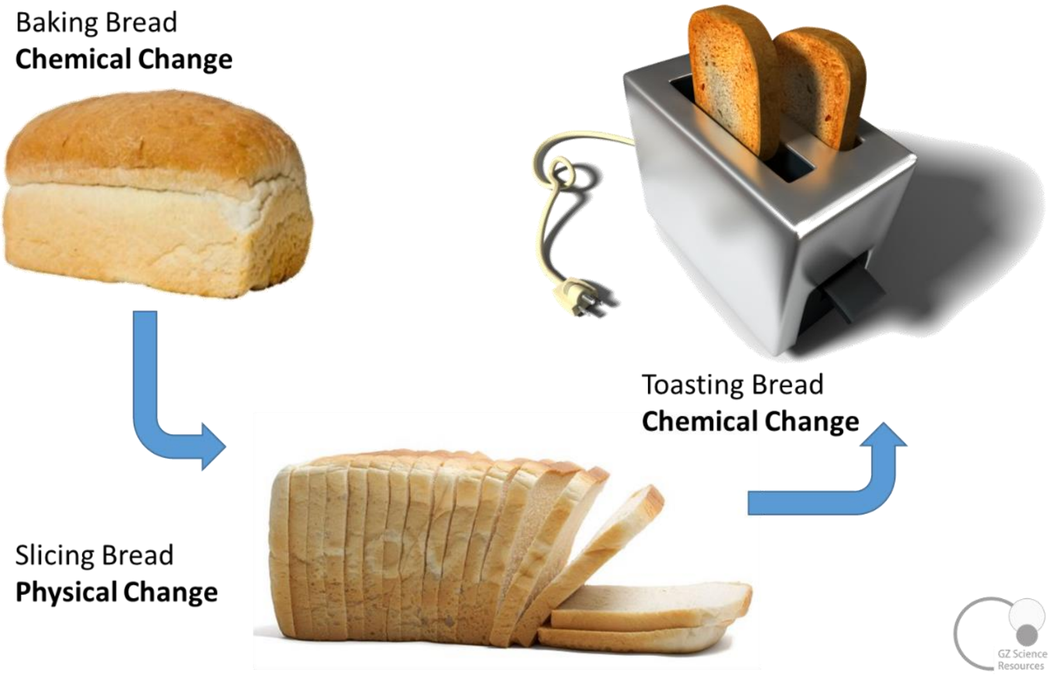
Burning sulphur – creates a new smell

Examples of Physical Changes

- ❑ crumpling a sheet of paper
- ❑ melting an ice cube
- ❑ breaking a bottle

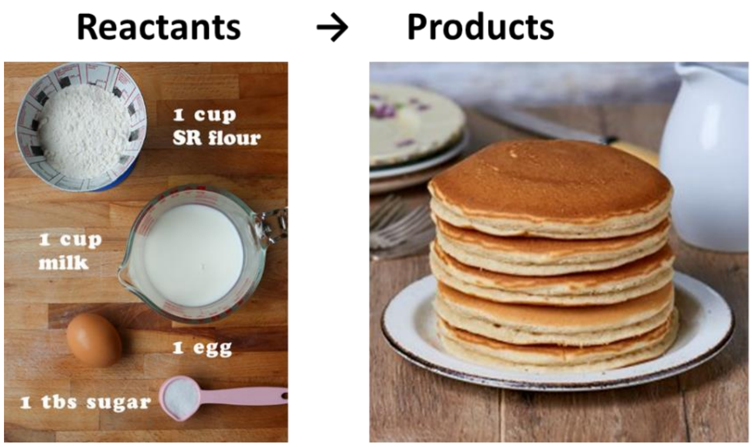
No change in temperature, colour, gas or smell

Chemical and Physical change in everyday situations



Reactants and products in a chemical change

A chemical change is a process that produces a chemical change to one or more substances. A chemical change will produce a new substance. Other observations may include a temperature change, a colour change or production of gas. Chemicals that are used, and you start with, in a chemical change are known as reactants. Those that are formed are known as products.



For example: making pancakes is a chemical change.
The reactants (ingredients you start with) are flour, milk, egg and sugar.
The product is pancakes.

Chemical equations

We show chemical changes as equations. All reactants must go to the left of the arrow and all products go to the right of the arrow. An arrow must be used and not an equals sign. The arrow shows a chemical reaction, where the reactants change into products.