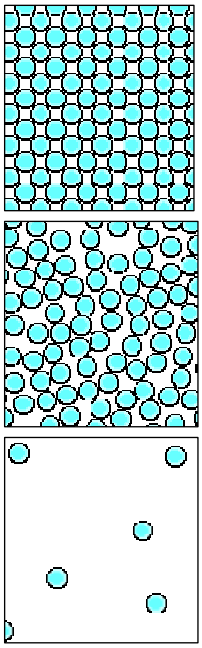
Particles & the atom

- All materials are made of very, very small particles held together by forces. Matter has mass and occupies space; there are three states of matter - **solids, liquids** and **gases**. Mass is the amount of matter in an object; it is measured in kilograms or grams, using a balance.
- Density is how much mass is packed into a measured volume. Density is calculated as follows: Density(D) = Mass(M) ÷ Volume(V). It has the units: Density - g/cm³, Mass - g or kg, Volume - cm³ or m³. Mass is measured on scales or balances. Volume is measured by calculation for regular objects or by displacement of water for irregular shapes. N.B. The density of water is 1g/cm³. Objects with a lower density float, those with a higher density sink.



- Solids: In a solid the particles are held very close together so they can hardly move. They do not flow like liquids, they keep their shape and they generally stay in one place.
- Liquids: In a liquid the particles are not so tightly packed, so they can move a little. Liquids flow easily and change their shape, and take the shape of the container they are in. Liquids always take up the same amount of space so when liquids change shape their volume stays the same.
- Gases: The particles are spread apart and can move easily and freely in a gas. Gases change their shape and can be squashed (compressed) as there is a lot of space between the particles.
- Ease of compression order: gases >>> liquids > solids (almost impossible to compress a solid)
- The three states of water are solid - ice, liquid - water and gas - water vapour. A common mistake is to say “steam”. Steam, e.g. from a electric jug, is a mixture of water droplets (tiny particles of liquid which you can see) and water vapour (a gas which you can't see).
- Matter can be changed from one state to another when heat is added/removed; changes of state are boiling, evaporating, condensing, subliming, melting, & freezing (solidifying).
- Heat will change a material from a solid to a liquid to a gas. A solid melts into a liquid when it is warmed. A liquid evaporates into a gas when it is warmed. Removing heat (cooling) will change a material from a gas to a liquid to a solid. A gas condenses into a liquid when it is cooled. A liquid freezes into a solid when it is cooled. Sublimation is when a solid, on heating, directly changes into a gas, AND the gas, on cooling, re-forms a solid directly.
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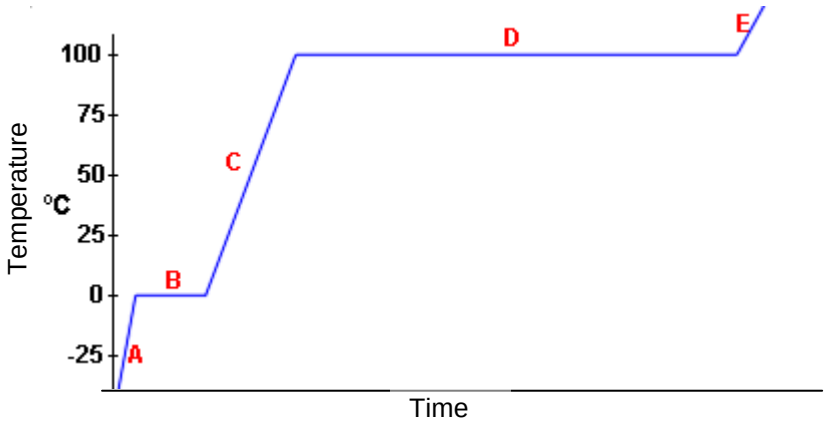
Substance	Melting Point (^{O}C)	Boiling Point (^{O}C)	State at 20^{O} C
ethanol	-114.	78	liquid
carbon (diamond)	3500	3930	solid
copper	1083	2300	solid
gold	1063	2856	solid
hydrogen	-259	-253	gas
mercury	-39	357	liquid
oxygen	-218	-183	gas
water	0	100	liquid

Eg ethanol melts at -114^{o}C but doesn’t boil until 78^{o}C so it will be a liquid at room temperature (20^{o}C).

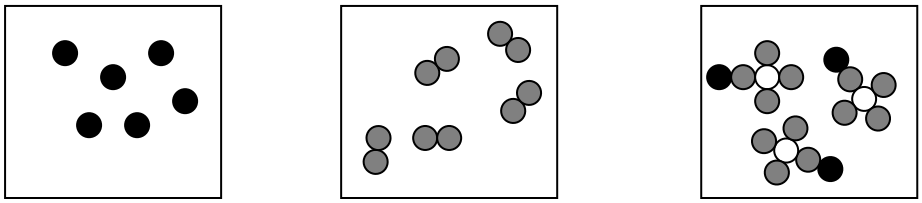
- A heating curve summarises the changes solid → liquid → gas. The temperature stays constant during the state changes of melting and boiling because all the energy absorbed in heating at these temperatures goes into weakening the forces between the particles without temperature rise.



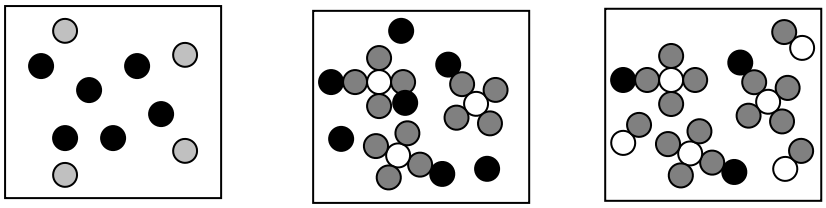
A – solid
B – solid/liquid = MELTING (melting point is $0^{o}C$)
C – liquid
D- liquid/gas= BOILING (boiling point is $100^{o}C$)

- A cooling curve summarises the changes gas → liquid → solid. The temperature stays constant during the state changes of condensing and freezing.
- Expansion and contraction. As objects are heated the particles move apart and they take up move space - expansion. As objects cool the particles move closer together, they take up less space - they contract. Some everyday examples are: The sag in outdoor electrical cables is much greater on hot summer days than it is on cold winter days; the rails for trains are installed during warm weather and have small gaps between the ends to allow for further expansion during very hot summer days; A stuck metal lid on a glass container can be loosened by running hot water over the joint between the lid and the container, because the metal expands more than glass.
- Bimetallic strips. When heated, a strip of steel would expand less than an equal length piece of aluminium. Welding together a thin piece of each of these materials produces a bimetallic strip. The difference in expansion causes the bimetallic strip to bend when the temperature is changed. This movement has many common uses including: thermostats to control temperature, oven thermometers to measure temperature, and switches to regulate toasters.
- When a substance dissolves, it is said to be soluble. Substances which do not dissolve are insoluble. A solute is a substance that dissolves in a solvent to form a solution. In a suspension the solid settles to the bottom when left standing. Solutions do not settle.
- A dilute solution contains only a small amount of solute in a given volume of solvent. A concentrated solution contains a large amount of solute.
- Diffusion. Diffusion is the gradual mixing of substances caused by the random movement of particles. If a crystal of potassium permanganate is put in the bottom of a beaker of water, the purple crystal dissolves and then the colour spreads throughout the water in quite a short time due to the random movement of water particles. This spreading out is called diffusion. Diffusion is faster in hotter water than at room temperature water as the water particles are moving faster and colliding with more energy. Diffusion occurs fastest in gases – you can smell cooking in the kitchen as soon as you open the front door. The smaller the molecules, the faster the rate of diffusion.
- Atoms are the basic building blocks of all matter. A molecule is two or more atoms joined together by chemical bonds.

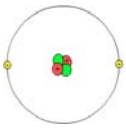
- An element is a pure substance made of atoms of only one type. It cannot be decomposed into simpler substances by chemical reactions. There are about 100 different elements, each with its own symbols. Elements can be single atoms (eg box with 6 atoms) or molecules (eg box with 5 molecules, each made up of 2 atoms), but both only contain only ONE1 type of atom



- A compound is a pure substance made up of two or more different elements that are chemically joined together. The chemical formula for a compound tells you what elements it contains. It also tells you the ratio of the atoms of the elements. Eg $CuSO_4$
- Mixtures contain two or more different substances. (They could be mixtures of elements, mixtures of elements and compounds, or mixtures of compounds).



- Chemical reactions produce new substances by rearranging atoms. The compounds that are formed have different properties from the original substance(s) with properties different from the original substance. Eg magnesium (a silvery grey metal) burns in oxygen (a colourless gas) with a bright white flame to make a new substance called magnesium oxide (a white powder)
- Atoms are composed of a positively charged nucleus surrounded by tiny negatively charged electrons. Inside the nucleus are protons (positive charge) and neutrons (no charge).



- Know the rules for "building atoms" : atomic number = no. of protons and no of orbiting electrons; mass number = number of protons + neutrons. Electrons are found in regions called shells (energy levels). 1st shell holds up to 2 electrons. 2nd and 3ro shells up to 8 electrons each.
- Properties (chemical and physical) of common metals are related to their uses eg

Copper	Iron	Aluminium
Water pipes, electrical wires, bottoms of saucepans	Bridges, gates, car bodies, reinforcing concrete	Aircraft, overhead electricity cables, cooking foil, drinks cans
Copper is a good electrical conductor, good heat conductor and doesn't corrode.	Hard, strong, cheap BUT it does corrode when in contact with air and water. (When iron corrodes we call this rust.)	Aluminium is shiny, non-toxic, low density (light for its size), good electrical conductor, and doesn't corrode.

- Some common elements

Element	Physical property	Chemical property
Magnesium	Silvery grey metal, bendy	Burns with a bright white flame
Sulfur	Dull, yellow, brittle, solid non-metal	Burns with a blue flame to make a choking gas
Hydrogen	Lighter than air, colourless, odourless gas	Burns with a squeaky pop if lit with a match
Mercury	A silvery metal that is liquid at room temperature	Poisonous

- Elements vary in their appearance and state. There are many more metals than non-metals.

Property	Metals	Non metals
Appearance	Shiny	Dull
Melting and boiling points	High (they are all solid at room temperature, except mercury which is a liquid)	Lower than metals (bromine is a liquid at room temperature, and eleven others are gases).
Density	High (they feel "heavy" for their size)	Low (they feel "light" for their size)
Strength	Strong (they can hold heavy loads without breaking)	Not strong
Malleability	Malleable (they can be hammered into different shapes without breaking).	Brittle (they break or shatter when hammered).
Ductility	Ductile (they can be drawn out to make wires).	Not ductile.
Heat conductivity	Good	Poor
Electrical conductivity	Good	Poor (but graphite, a form of carbon, is an exception).

- Materials have properties – things that tell us what its like eg hard, soft, light, strong, heavy, flexible (bendy), transparent, texture (rough or smooth). Glass, metal, ceramics and plastic could all be used to make a cup. Each has properties that make it suitable but each may have disadvantages.
- Different materials are used for different purposes as their properties make them suitable, eg copper, glass, lead, limestone, Perspex, polystyrene, rubber, steel, wood.