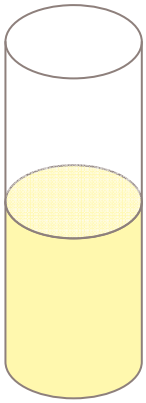
What's the Matter?

Everything around is made of matter, but substances are not just solid or liquid stuff: gases are also matter. So, matter can exist in three forms: solid, liquid and gas. We call them *states of matter*.

A solid has a definite volume and shape.

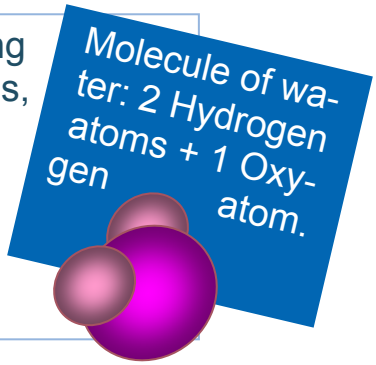


A liquid can flow and has a definite volume, but its shape changes according to the shape of the container.

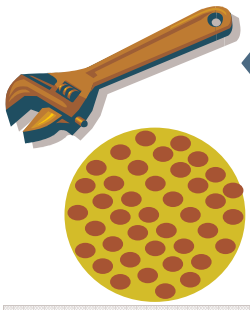
A gas has neither definite shape, nor definite volume, it will tend to fill all the space available.

Why substances can be found in nature as solids, liquids or gases?

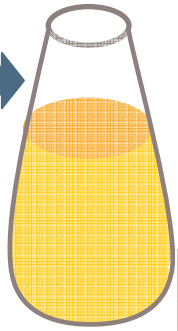
Scientists agree that substances are made of moving particles. Depending on the energy of these particles, solids, liquids and gases have different properties. Changing the amount of energy of the particles, it is possible to change the state of matter. All matters are made of tiny particles called atoms. Atoms can form molecules.

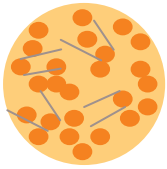


The molecules in any substance move around in all directions.

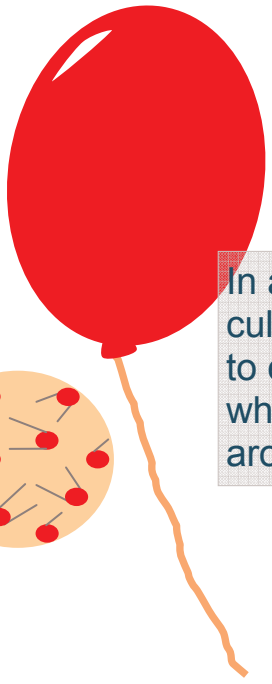


In a solid the particles are firmly attached to each other. They vibrate about a fixed point, so solids have a definite shape.





In a liquid the particles move around more easily, so they can flow and be poured.



In a gas the molecules are not attached to each other, that is why they can move around freely.

Water goes around in a never-ending cycle: the Sun heats the sea's surface and turns the water into water vapour. This process is called evaporation. Water vapour rises into the sky, where it cools and turns back into tiny droplets of water: condensation. The droplets form the clouds, and they grow until they are heavy and drop down as rain. Water runs over the land, seeps into the ground, flow into rivers and lakes and eventually back to the sea.

WATER CYCLE

The Sun's heat turns water into clouds of water vapour. This process is called *evaporation*.

Water vapour cools and turns into drops of water that fall down: this process is called *condensation*.

The water runs over the land into rivers and lakes and flows again into the seas.

Changes around us

Rain on a window glass

We can observe lots of these changes around us in our daily life. Some of these changes are reversible and we see substances melting and turning back again into as solid. We can observe the changes of state of water around us all the time. It has a lot to do with climate, but it happens, also, at home, at school, everywhere... This process is called *the water cycle*.

Melting and boiling

When a solid is heated its temperature rises and its particles gain energy until it reaches its **melting point**: the particles now have enough energy to break away from their neighbours so the solid melts.

If you continue heating it, the temperature rises until it arrives to its boiling point and the particles break free of each other completely. Then, the liquid becomes a gas.

Boiling water

Always?

No, not always: some substances change from gas to solid or solid to gas without passing through a liquid form. Carbon dioxide is one of these substances.

Mixtures

If a substance is a mix of substances, the melting point, boiling point and freezing point change.

What about pressure?

We have seen that pressure influences in the change of state of matter. The higher we are over the sea level, the lower the atmospheric pressure and its easier for the particles of liquids to escape into air. At the sea level pure water boils at 100ºC, but at the top of Mount Everest, it boils at 71ºC.

Is it a solid, a liquid or a gas?

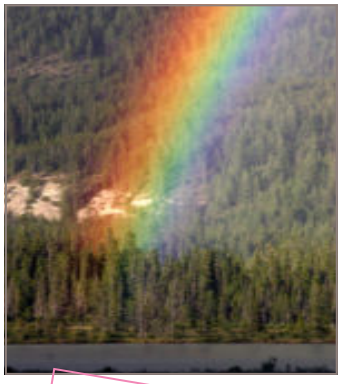
We have seen that it all depends on temperature and pressure. So, we consider that a substance is a solid, a liquid or a gas considering its state at room temperature. (20ºC).

When it is very cold the droplets in the atmosphere freeze, form tiny crystals and they fall in form of snowflakes.

Altitude affects evaporation.

How Liquids Behave

Liquids have not a fixed shape: they adapt to the container where they are held in!!



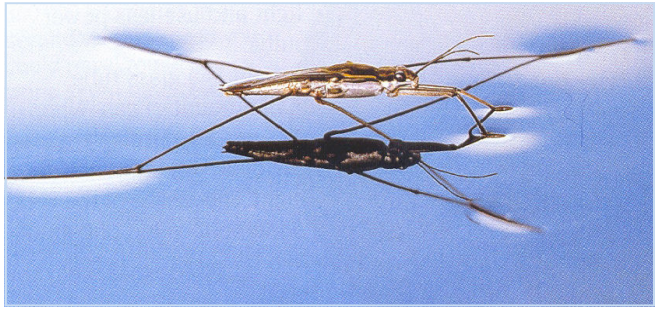
Raindrops split sunlight into different colours and form the rainbow.

Liquids have a definite volume. The same amount of liquid in different containers looks different but it still has the same quantity of liquid, the same volume!!

When tiny droplets of water in the atmosphere freeze, they sometimes join together in beautiful patterns of crystals and form snowflakes like these.

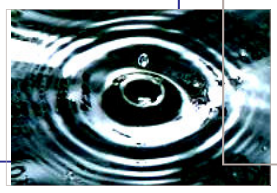
Surface Tension

The molecules in a liquid are attracted by all the other liquid molecules around them. The ones on the surface are not pulled upwards because there are not liquid molecules above them. They are more attracted to the particles of water than to the air, so the surface works like a thin skin: the sideways and downwards attraction at the surface creates a force called surface tension.



Pond skaters can walk over the water.

Image from Oxford Encyclopedia



Liquids flow, can splash and can be poured. Some liquids are denser than others.

Measuring matter

Mass, Volume and Density

Mass: all matter has mass. We know how much matter there is in an object by measuring its mass. Mass is measured in kilograms or grams.

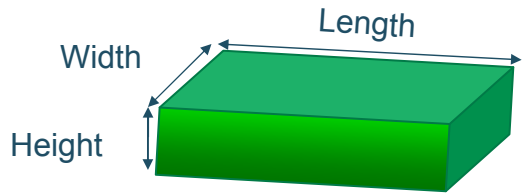
Volume: matter occupies space. This space is called volume. Volumes are usually measured in litres and either in cubic metres or in cubic centimetres.

Density: density is the quantity of mass per volume. When an object has a lot of mass for its volume, this object has high density. Other objects are larger (have more volume) but they have little mass, it means that they have low density. In nearly all substances the solid state is the densest, liquid state is less dense and gaseous state is the least dense.

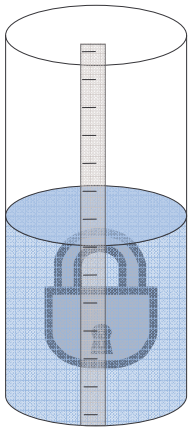
volume

We can work out the volume of a solid object. If it is a regular object, such a rectangle, it's easy:

Length x Width x Height = Volume

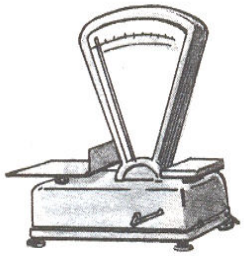


We can calculate the amount of space occupied by an irregularly shaped solid object by submerging it into a liquid and measuring how many liquid displaces. And, to know the volume of a liquid we can use a measuring cylinder or any other measuring container.



mass

The mass of a solid, liquid or gas is the amount of matter it contains. This is measured in kilograms. Mass is measured by weighing a substance using scales, or a balance and comparing its mass with a known mass.



Scales are used for weighing objects and products.

density

Density is the mass of a substance compared with its volume. Same volumes of two substances can have different densities because the mass of one of them is greater than the other. We can work out density by dividing the mass of an object by its volume, and it is measured in kilograms per cubic metre (kg/m^3). The density of a liquid can be measured using a hydrometer.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

How Gases Behave

Gas Molecules

The molecules in a gas are not attracted to the other molecules around them. They do not stick together, so they tend to spread out quickly and occupy all the space available. That is why they have no shape of their own.

Most gases turn on into liquids when cooled at a very low temperature: Oxygen liquefies at 183 degrees Celsius below de freezing point (-183°C).

Heating up

By heating something we give it more energy. When a material is heated, molecules spread out and materials expand. When we cool them down, they contract again.

Floating up!!

Air expands a lot when is heated and it gets much lighter; this is why warm air always goes up. Balloons can float in the air around because the air inside the balloon is heated.

Some gases are extremely flammable. Picture of a propane explosion.

dew

One of the gases present in the air around us is water vapour. As the air temperature falls in the early morning, some of this atmospheric water vapour condenses on cool surfaces as tiny drops of liquid water. It the temperature falls below freezing point they get *frost* and form small white ice crystals on the ground or on other surfaces where dew is deposited.

Mixing Materials

In the natural world, and in our daily life, most things are made of lots of different substances mixed up together. Materials and substances can be mixed together to get new materials. These new materials use to have different properties than the ingredients by themselves. Some mixtures are called solutions.

Mixtures

In a mixture, sometimes, materials are combined but their molecules do not change and the materials mixed behave in the same way as the separate substances.

Reactions

Sometimes materials react with each other, so, when they get mixed, their molecules change and they turn into different materials.

Solutions

A solution is a special kind of mixture in which one substance (the solute) is dissolved in another (the solvent): in salty water the salt will remain evenly spread throughout the water. This does not happen mixing sand and water: the sand will settle on the bottom.

Separating Mixtures

Ingredients of mixtures can be separated in various ways depending on the chemical compounds:

- Filtering and sieving.
- Skimming.
- Spinning
- Evaporating or distilling...

Saturation

A solvent can only dissolve a certain amount of a substance. When you cannot solve more of a substance and it piles up at the bottom of the container, the solution is saturated.

These two buildings are made of a mix of materials: the picture on the left is from San Francisco (USA) and the building is made of concrete. The picture on the right is from Morocco and the building is made of a mix of clay and straw, which is far less stronger than concrete. Erosion spoils these buildings pretty easily and that's why it is not used to build huge buildings like the Transamerica Tower (left). These are two examples of mixed materials used in construction.