UNIT 6 MATTER AND ITS PROPERTIES.

KEY CONCEPTS

- A body's mass is related to the amount of matter it has.
- A body's volume is the measurement of the body's size.
- A volume of 1 dm^3 has a capacity of 1 l.
- Density is the relationship between the mass of a body and the volume it occupies.
- Solids, liquids and gases are the three states of matter.
- Kinetic Particle Theory allows to explain these states and changes between them.

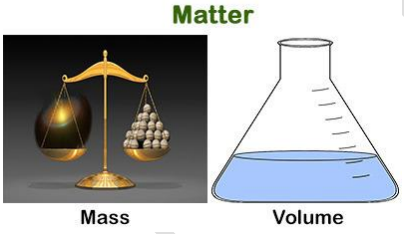
1. MATTER HAS MASS AND VOLUME

All objects around us have **mass**. Solids, liquids or even gases have mass because it is a property of matter.

The **mass**, *m*, of an object is the amount of matter it contains. The greater the matter of an object, the greater its mass. Its SI unit is the **kilogram (kg)**.

We already know that mass has dimensions. These dimensions are what we define as the **volume** of a body.

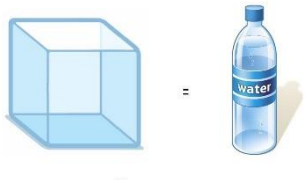
The **volume**, *V*, of a body is defined as the space that this body occupies. The unit of measurement in SI units is the **cubic metre (m^3)**.



The cubic metre is often too big to measure the volume of some bodies, so usually we use multiples or submultiples of this unit. The most commonly one is the cubic centimetre (cm^3).

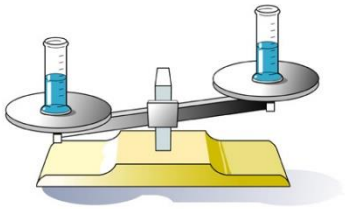
We use many different containers of a particular volume to hold gases and liquids. We say that a certain volume has a certain **capacity**, and this capacity is expressed in other units, known as **units of capacity**. The most familiar one will surely be the **litre** (l). If you measure the dimensions of a milk carton and express the volume in cubic decimetres, you will see that a volume of 1 litre carton of milk is 1 dm^3. We say, therefore, that:

A volume of 1 dm^3 has a capacity of 1 l. That is: **1 l = 1dm^3**.



1000 cm^3 = 1 litre = 1000 ml

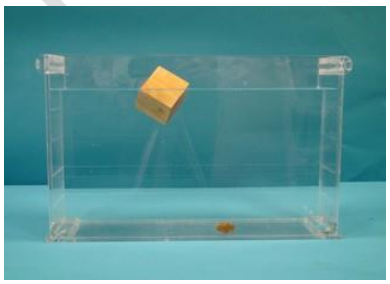
2. DENSITY



Identical volumes from different substances can have different masses because matter does not always occupy de same space. For example, if we measure de same amounts of water and alcohol, we observe that water is the heaviest. We say that water is denser than alcohol.

The **density**, d, of a substance is defined as the relationship between its mass and its volume.

$$d = \frac{m}{V}$$



Different volumes from the same substances will have diferent masses, but relationship between them remains constant because they have the same density. Density is a property of matter that doesn't depend on the amount of the substance.

2.1. Units of density

Density is measured in units of mass per units of volume. Therefore the unit of density in **SI units** is **kg/m^3**. But usually, we don't work out with amounts of substances as bigger as cubic metres. That's why, density is often expressed in **g/cm^3**.

Substance	Wood (oak)	Oil	Water	Aluminium	Iron	Lead	Mercury	Gold
Density (g/cm^3)	0,65	0,9	1,0	2,7	7,8	11,4	13,6	19,3

2.2. A common mistake: is density the same as viscosity?

We use to think that oil is denser than water, but making calculations we can see that this is not the case. The reason for this is that oil is more viscous than water.

Viscosity is defined as the fluid's resistance to flow.

If you pour water and oil separately into a frying pan, you will see that the water slides easily across the surface, whereas the oil will move very slowly. Water is more dense but less viscous than oil.

3. STATES OF MATTER

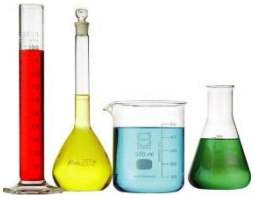
Matter is all around us. Anything we look at, from hard rocks or the deep blue sea to the invisible air, can be found in three **states: solid, liquid** or **gaseous**.

The states of matter have properties that are very different from each other and that makes them behave in different ways.

Solids

Solids don't change both shape or volume, even if we put in a different containers. Solids have a constant shape and volume.

Liquids



Liquids change shape if we transfer it from one container to another. However, their volume doesn't change. So if we have a litre at the beginning, it will always be a litre.

Gases

Gases maintain neither the shape nor the volume. Both of them will depend on the shape of the container holding the gas.

Summarising:

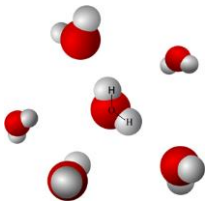
SOLIDS	LIQUIDS	GASES
Invariable shape	Variable shape	Variable shape
Constant volume	Constant volume	Variable volume

As you can see, all liquids and gases change their shape according to the container holding them. However, only gases take up the entire volume of the container they are in.

4. THE KINETIC PARTICLE THEORY

- When we hang out our clothes newly washed and wet, after a while, they are dry. What happened with the water there was inside the clothes?
- How it smells! How can we explain why smells spread out for the whole house?

These phenomena are the basis for the **Kinetic Particle Theory** (also called **Kinetic Theory of matter**).

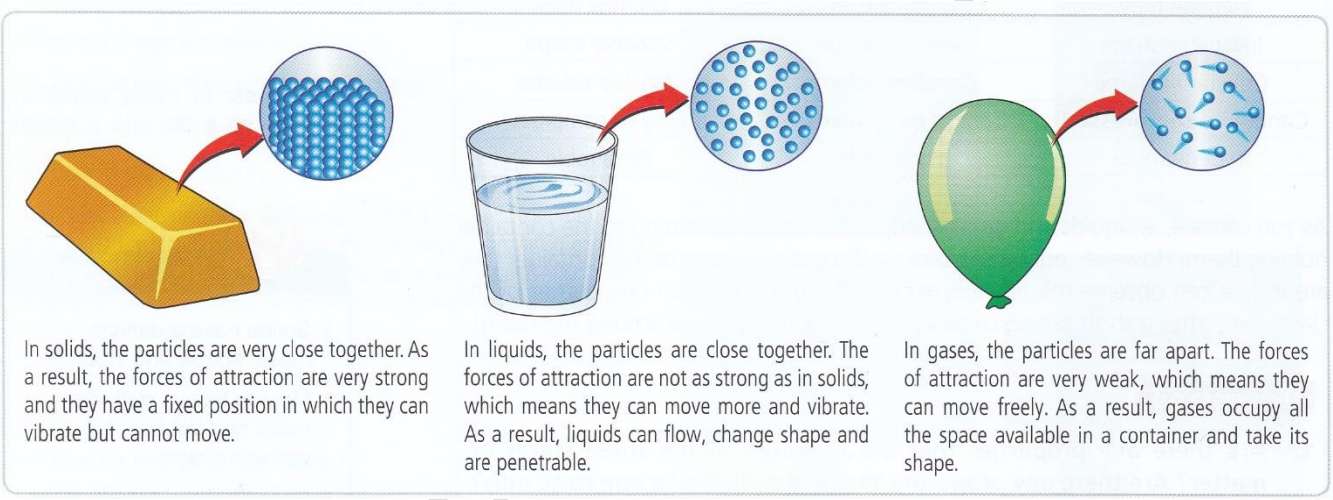


Scientists believe that matter is composed of very small particles. These particles are so small that they cannot be seen to the naked eye. These particles can be atoms, molecules (with two or more atoms) or ions (particles with electric charge). For example, water is composed of molecules and these, by atoms.

Kinetic Particle Theory states:

- Matter is composed of particles (atoms, molecules or ions) that are in some way attracted to each other.
- These particles are in constant motion. As the temperature rises, the speed of the particles increases.

From these statements, this theory allows us to explain the three states of matter:



In solids, the particles are very close together. As a result, the forces of attraction are very strong and they have a fixed position in which they can vibrate but cannot move.

In liquids, the particles are close together. The forces of attraction are not as strong as in solids, which means they can move more and vibrate. As a result, liquids can flow, change shape and are penetrable.

In gases, the particles are far apart. The forces of attraction are very weak, which means they can move freely. As a result, gases occupy all the space available in a container and take its shape.

The state of matter depends on how close together (or aggregated) the particles are. So we talk about the **state of aggregation of matter**.

5. CHANGES OF STATE

You have probably seen haw an ice cube melts when you take it out of the freezer or how water boils into water vapour.

Kinetic Particle Theory helps us to explain these changes in states of matter depending on the temperature from the environment.