UNIT 7. MATTER, FORCES AND MOTION

Matter

The Universe is made up of matter and energy and empty space. Everything around us, living and non-living, is made up of matter: plants, animals, books, tables, the food we eat and the water we drink. Even the air we breathe is made up of matter.

Matter can't be created or destroyed; it just changes from one state or form to another. How many states of matter are there in the universe?

Questions

- What are the states of matter in the following examples? a bowl of noodle soup, a gas cylinder, a frozen lake
- Which has more mass: a kilogram of feathers or a kilogram of iron? Which has more volume? Why?
- Why do you think a small stone sinks in water while a giant cruise ship floats?
- Sometimes cruise ships sink. Why does this happen?
- Is sea water a mixture? What is made of?
- Which force makes a parachute fall? Which is the force that makes a parachute go down slowly?
- Search for information about what materials a parachute is made of. Are they natural or man-made materials?

Do you remember?

Solids

Definite volume. Definite shape. They occupy space and have mass. We can hold them in our hands.

Liquids

Definite volume. Indefinite shape: they take the shape of the container. Liquids occupy space and mass.
We cannot hold liquids in our hands. We can hold them if they are placed in the container.

Gases

Indefinite volume: they can be compressed. Indefinite shape: they take the shape of the container. Gases occupy space.
You cannot see most gases (like air).

Changes of state

- Sublimation: from solid to gas
- Deposition: from gas to solid
- Melting: from solid to liquid
- Solidification: from liquid to solid
- Condensation: from gas to liquid
- Evaporation: from liquid to gas

Changes in materials

Physical changes

To make an origami figure, you make many folds in a sheet of paper. The material takes on a different shape, but it is still paper and still has the same properties. Some physical changes, such as changes of state, are reversible, while others are irreversible. Sharpening a pencil is irreversible as you cannot put the pencil shavings back onto the pencil.

Chemical changes

When wood burns (combustion) it's transformed into other substances. These new substances include ashes and smoke and have different properties from the original wood. Other chemical changes include oxidation of metals when in contact with air, or the fermentation of milk, which gives us custard and yoghurt. Most chemical changes are irreversible.

Irreversible changes

Irreversible changes, like burning, cannot be undone.

Reversible changes

Reversible changes, like melting and dissolving, can be changed back again.

Matter and its properties

Matter is everything around us. Matter is made out of tiny particles called atoms. Some atoms join together to make groups know as molecules.

The molecules game

Solid, liquid and gas.

Properties of matter

Apart from its size, shape, texture, colour, odour and taste, matter has other properties and can be found in three different states.

1. Volume describes how much space matter occupies. A car has a larger volume than a bicycle. We measure volume in millilitres (ml). 1000 millilitres = 1 litre.
2. Mass is the amount of matter in an object. An apple has a greater mass than a grape. We measure mass in grams (g). 1000 grams = 1 kilogram.
3. Density is the amount of matter in a volume. We measure density in kilograms per litre (kg/l). density = mass/volume. Density explains why some objects float in water while others sink.
4. Hardness is the scratch-resistance of a solid. Diamonds are the hardest natural solids.
5. Solubility is the ability of a substance to dissolve in other substance and form a solution. Sugar dissolves well in water, whereas oil does not.

What types of matter are there?

According to its composition, we can classify matter into pure substances and mixtures.

Pure substances

Pure substances, such as table salt or silver, consist of only one type of matter.

Mixtures

Mixtures are made up of two or more pure substances and can be homogeneous or heterogeneous.

- In a homogeneous mixture, such as the air we breathe or sea water, we cannot see the individual substances that make it up.
- In a heterogeneous mixture, such as sand or a salad, we can see the individual substances that make it up.

There are different methods to separate the substances in mixtures.

Filtration. When we pour the juice of a lemon through a filter, the solids stay in the filter, and the liquid passes through it.

Evaporation. When we heat a mixture of salt and water, the liquid evaporates and leaves only the solids which crystallise and form salt crystals.

Sieving. We use a sieve to separate solids of different sizes, such as pebbles from sand.

Questions

- What is the relationship between matter and volume called? What does it explain?
- In your notebook, identify pure substances (PS) and mixtures (M). gold, chocolate, oxygen, sea water, iron, soft drink
- Which method would you use to separate the following mixtures? salt from seawater, mud from water, rice from beans
- Name three substances which dissolve in water and three substances which don't dissolve in water.

Did you know?

Smog is a heterogeneous mixture of gases and very small particles from vehicle exhaust and factory emissions. Smog is very harmful to our health and to the environment. What two words were combined to make the word 'smog'?

Forces and their effects

A force is a push or pull that acts on an object. We can't see forces, but we can see and feel their effects. Forces can make things move, stop, speed up, slow down, or change direction. Forces can also make things change shape.

Some forces act from a distance. These forces are called non-contact forces. Other forces act through physical contact. These are called contact forces.

Non-contact forces

Magnetism

Magnetism is a force of attraction or repulsion caused by magnetic materials. Magnets attract metals and also make compasses work.

Gravity

Gravity is a force which attracts all objects towards each other. Larger bodies, such as planets, have a stronger gravitational force. Gravity stops everything on Earth from flying off into outer space and also causes objects to fall to the ground. Astronauts float in space, because there is no gravity there.

Contact forces

Friction

Friction is the force that exists when two objects rub against each other. Friction acts in the opposite direction to the direction of movement. It can slow down or stop a moving object. Air friction slows down a parachute and water friction slows down a kayak or a boat.

Buoyancy

Buoyancy is the ability of objects to float. It is an upward force which acts in the opposite direction to gravity on objects immersed in a liquid. If you put an ice cube in a glass of water, gravity pulls the ice cube down and the buoyant force pushes it up. The submerged ice cube displaces some of the water and, as a result, the level of water arises.

Why some objects float in water and others sink

Density explains why some objects float in water while others sink. Look at the densities of cork, water and iron.

cork: 0.25 kg/l water: 1.00 kg/l iron: 7.90 kg/l

Cork has a lower density than water. This is why cork floats in water. Iron has a higher density than water. This is why it sinks in water.

The density of steel is around 7.7 to 8.0 kg/l. Why do ships float if they are made of steel which has a bigger density than water?

The ability to float depends on the average density of the object. Average density takes into account the steel that the ship is made of and the air that is trapped in the body of the ship.

Questions

- What would happen if there was no gravity? What would happen if there was no friction?
- Name the force that is involved when you apply the brakes on your bike. Do you think this force is helpful in this case? Why?
- Why does ice float in water? What does this say about density of water and ice?
- Look at the following table. If you wanted to build a toy boat, which material would you use? Why? material: density water: 1 kg/l plastic: 1.1 kg/l oak wood: 0.8 kg/l

A new world of materials

Nearly everything we use is made of materials that have been created or modified by scientists and engineers to make them perform better. Man-made materials have transformed our everyday life.

Polymers

A polymer is a large molecule, or macromolecule, composed of many repeated subunits (many small molecules called monomers). There are synthetic and natural polymers, and they play an important role in our life.

Synthetic plastics such as polystyrene or nylon and neoprene are synthetic polymers. DNA and proteins or latex rubber and cellulose are natural polymers.

Alloys

Many elements found in nature, such as gold and aluminium, can't be used in their pure form because they are too soft, too brittle or rust too easily. It is necessary to create an alloy by mixing two or more elements, one of which must be a metal. Brass, for example, is an alloy of copper and zinc. Steel is one of the most commonly used alloys, and it is made of iron, carbon and other elements.

Ceramic materials

Today, surgeons can replace hip and knee joints with artificial joints made of a special ceramic material which is hard and long lasting and has no side effects on the body.

A ceramic material is also used by dentists to repair teeth which have developed cavities.

The black non-stick Teflon-PTFE coating on cookware is being replaced by a non-stick ceramic coating. This new material tolerates heat better, don't peel off ad doesn't release harmful chemicals into the food we eat.

Computer chips

Computer chips are made up of 60 different materials, of which 11 are rare Earth elements.

Recycled materials

Perhaps you are wearing something that used to be a plastic bottle!

Polar fleece fabric is a type of material that can be manufactured from recycled plastic bottles. This material is soft, lightweight and has good insulation properties. Often blankets, jackets, hats and athletic garments are made from this fabric.