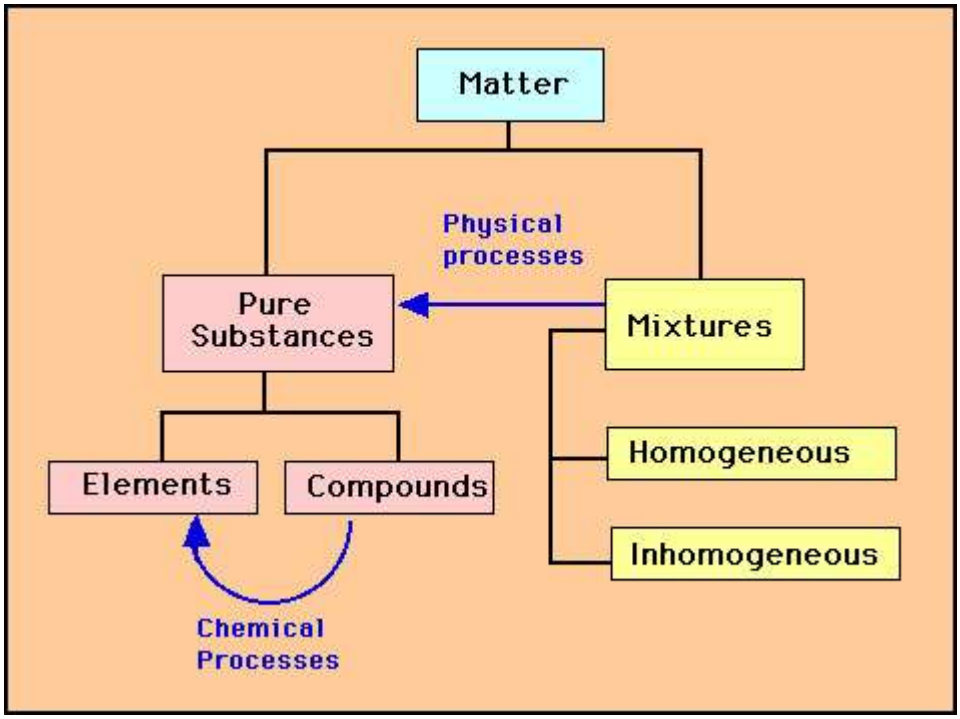
Elements, Compounds and Mixtures



Lavoisier, a French chemist on the basis of quantitative studies classified pure substances into elements and compounds. He showed that when we heat mercuric oxide it changes into mercury and oxygen.

Mercuric oxide is a compound because it decomposes into simpler substances, whereas mercury and oxygen cannot be further decomposed into anything simpler as they are elements.

Elements

It is defined as a substance that cannot be further reduced to simpler substances by ordinary processes. Elements are made up of particles/atoms of only one kind. For example: Hydrogen and oxygen There are 118 elements known. Out of these 92 of them occur in nature.

Types of elements:

- **Metals:** They are generally solids with characteristics such as hardness, malleability, ductility high tensile strength, lustre and ability to conduct heat and electricity.

  For example: Copper, iron, zinc etc.

- **Non-metals:** They are generally non-lustrous, brittle, poor conductors of heat and electricity.
  For example: Sulphur, phosphorus, nitrogen etc.
- **Metalloids:** These elements have characteristics common to metals and non-metals.
  For example: Arsenic, tin, bismuth etc.

Compounds

It is a pure substance that can be decomposed into simpler substances by some suitable chemical technique. A compound is formed by combination of two or more elements in a definite proportion. For example, water is a compound of hydrogen and oxygen elements present in the ratio of 1: 8.

Properties of compounds:

- A compound cannot be separated into its constituents by mechanical or physical means.

For example, if we bring a magnet near a sample of iron sulphide, the iron present in the iron sulphide cannot be separated.

- Properties of a compound differ entirely from those of its constituent elements.

For example, water is made up of hydrogen and oxygen. However, the properties of hydrogen and oxygen (both gases) are different from water (liquid). Hydrogen is combustible, oxygen is a supporter of combustion whereas water (made up of both hydrogen and oxygen) puts out a flame.

- Energy changes are involved in the formation of a compound. For example, iron and sulphur reacts only when heat is supplied.
- The constituent elements in a compound are in a fixed proportion by weight. In water, hydrogen and oxygen are present in a fixed ratio of 1:8 by weight.
- A compound is a homogenous substance. That is it is same throughout in properties and composition.
- A compound has a fixed melting point and boiling point. For example, ice melts at $0^{o}C$.

Mixtures

A mixture is a material containing two or more elements or compounds that are in close contact and are mixed in any proportion. The components of a mixture can be separated by physical means.

For example, air, gun powder, etc.

Properties of a mixture:

- A mixture may be homogenous or heterogeneous. A homogenous mixture has a uniform composition throughout its mass. For example, sugar or salt dissolved in water, alcohol in water, etc. A heterogeneous mixture does not have a uniform composition throughout its mass. There are visible sharp boundaries.
  For example: Oil and water, salt and sand, etc.

- The constituents of a mixture can be separated by physical means like filtration, evaporation, sublimation and magnetic separation.
- In the preparation of a mixture, energy is neither evolved nor absorbed.
- A mixture has no definite melting and boiling point.
- The constituents of a mixture retain their original set of properties. For example, sulphur dissolves in carbon disulphide and a magnet attracts iron filings.

Types of mixtures:

Matter	Mixture type	Example
Solid	Solid mixture	Iron filings and sulphur
Solid	Liquid mixture	Common salt and water
Solid	Gas mixture	Air entrapped in soil
Liquid	Gas mixture	Oxygen dissolved in water
Gas	Gas mixture	Air containing hydrogen, oxygen, nitrogen, carbon dioxide etc.
Liquid	Liquid mixture	Water and alcohol

Differences between mixtures and compounds:

Mixtures	Compounds
A mixture can be separated into its constituents by physical processes (filtration, evaporation, sublimation, distillation)	A compound cannot be separated into its constituents by physical processes. It can be separated by chemical means
A mixture shows the properties of its constituents	A compound has a new set of properties different from its constituents
Composition of a mixture varies and the constituents are present in any proportion by weight. It does not have a definite formula	The composition of a compound is fixed and the constituents are present in fixed proportions by weight. It has a definite formula
The constituents do not react chemically, thus no energy changes take place	Chemical reactions take place and energy changes in the form of heat and light are involved
A mixture does not have a fixed melting point and boiling point Examples: air, sand and salt	A compound has a fixed melting point and boiling point Examples: H_2O (water), FeS (iron sulphide)

Water is a compound and not a mixture

- The components hydrogen and oxygen cannot be separated by physical methods such as filtration, evaporation.
- Hydrogen and oxygen are present in a fixed proportion of 1: 8.
- Energy changes accompany the formation of a compound i.e., heat and light are given out.
- Properties of water are entirely different from the constituents, hydrogen and oxygen.
- The boiling point of water is 100°C at 76 cm Hg i.e., one atmospheric pressure.

Example: An unknown, clear liquid is given to you in a beaker. You transfer the liquid from the beaker to a clean, empty test-tube, and begin to heat it. After a while, you see vapours (which on further analysis you discover are vapours of water) rising from the test-tube, and pretty soon, all that's left are a few crystals of salt stuck to the edges! Was that liquid an element, compound or a mixture?

Solution: Mixture

The constituents of a mixture can easily be separated by physical processes, which in this case, was the application of heat. The salt had been dissolved in the water to form a true solution of common salt, where the particles of salt were invisible through the naked eye as well as through a microscope, resulting in the solution being absolutely clear.

Example: You have just won a block of pure 24-carat gold. Have you just procured an element, compound or mixture?

Solution: Element

Gold, like oxygen, hydrogen and over 100 other substances is classified as an element. Elements are further grouped into metals, non-metals and metalloids. 22-carat (or "karat") gold, or 22 parts of gold alloyed with 2 parts of silver or copper, is usually preferred to 24-carat (pure) gold in jewellery

Example: A dish is given to you, which contains a blackish-yellow powder. When you move a magnet over it, you are amazed to see black particles, (which you find out are iron) fly upwards and get stuck to the magnet, and all that's left in the dish is a yellow powder, which you discover to be sulphur (sulfur). Was your original powder an element, compound or mixture?

Solution: Mixture

The powder was a mixture of sulphur, which is yellow in colour, and iron, which is magnetic and blackish in colour. When the magnet was passed over the mixture, the iron got attracted to it, leaving the sulphur in the dish. Hence in mixtures, the properties of the constituents aren't lost

Example: A substance is analyzed in a laboratory, and when viewed under an electron microscope, it is revealed that it contains only one kind of atom. Is the substance an element, compound or mixture?

Solution: Element

An element is a substance which contains only one kind of atom. Oxygen contains only atoms of oxygen, uranium contains only atoms of uranium, sodium contains only atoms of sodium. The structure of the atoms of an element defines its properties.

Example: Water is what all life in the world depends on. Is it an element, compound or mixture?

Solution: Compound

A molecule of water is made up of two atoms of hydrogen and one atom of oxygen, which means that it is made up of more than one kind of atom, and hence isn't an element. Also, since it can only be broken down into hydrogen and oxygen (its constituent elements) by chemical processes (such as electrolysis), it is a compound.

Example: Aqua regia was a liquid used by alchemists to separate silver from gold. Was it an element, compound or mixture?

Solution: Mixture

Aqua regia was a mixture of concentrated nitric acid (HNO3) and hydrochloric acid (HCl) and was used to dissolve gold, which would leave silver.

Example: This gas is essential for us, and all other aerobic organisms, to survive. We inhale it along with the air we breathe (of which it forms approximately 21%) and it then helps in the oxidation of glucose in our bodies. When not in its molecular form, is it an element, compound or mixture?

Solution: Element

As you probably guessed, the gas is oxygen, of which the molecular formula is O_2.

Example: A magnesium ribbon is burnt in the air, to form the greyish oxide of magnesium - magnesium oxide (MgO). Is this oxide an element, compound or a mixture?

Solution: Compound

Magnesium oxide is made up of atoms of two different kinds - magnesium and oxygen, and hence is not an element. The ratio of magnesium: oxygen in it is a constant 1:1, and hence it is a compound.

Example: The air we breathe - is it an element, compound or mixture?

Solution: Mixture
Air is a mixture of several gases, with each of them retaining their own properties. Here's a brief outline of the composition of the air we breathe: Nitrogen - 78.1%; Oxygen - 20.9%; Argon - 0.9%; Carbon dioxide, methane, inert gases - 0.1%.

Example: These are given 'symbols' like 'Ar', 'Zn', 'W' and 'Xe', and are arranged in a table called the Periodic Table. Are they elements, compounds or mixtures?

Solution: Elements
While elements have 'symbols' to denote them, compounds have 'formulae' which show the presence of more than one element, such as H_2O' for water, 'NaCl' for common salt, etc

Assignment Problems

- Is mercury an element, compound, or mixture?

- element
- compound
- mixture

- Is table salt, sodium chloride, an element, compound, or mixture?

- element
- compound
- mixture

- Is (pure) water an element or compound?

- element
- compound

- What type of mixture is coffee?

- homogeneous mixture
- heterogeneous mixture

- What type of mixture is household vinegar?

- homogeneous mixture
- heterogeneous mixture

- What type of mixture is air?

- homogeneous mixture
- heterogeneous mixture

➢ Tap water is a(n)

- element
- compound
- homogeneous mixture
- heterogeneous mixture

➢ Fourteen carat gold is a(n)

- element
- compound
- homogeneous mixture
- heterogeneous mixture

➢ Carbon dioxide is a(n)

- element
- compound
- homogeneous mixture
- heterogeneous mixture

➢ Vegetable soup is a(n)

- element
- compound
- homogeneous mixture
- heterogeneous mixture

➢ The ocean is a(n)?

- element
- compound
- homogeneous mixture
- heterogeneous mixture

➢ Iron is a(n)

- element
- compound
- homogeneous mixture
- heterogeneous mixture

➢ Concrete is a(n)?

- element
- compound
- homogeneous mixture

- heterogeneous mixture

➢ Wood is an?

- element
- compound
- homogeneous mixture
- heterogeneous mixture