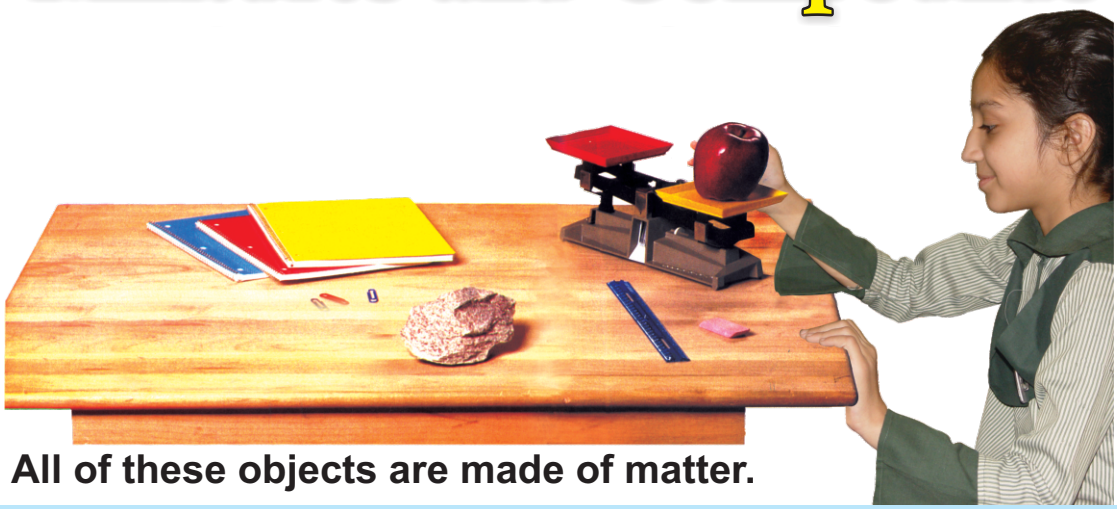
Chapter
5

Atoms, Molecules, Mixtures and Compounds



All of these objects are made of matter.

Student Learning Outcomes

After completing this chapter, you will be able to:

- Differentiate between an atom and a molecule.
- Recognize the symbols of some common elements.
- Classify elements into metals and non-metals.
- Relate the physical properties of elements to their uses.
- Differentiate between elements and compounds, compounds and mixtures.
- Identify examples of compounds and mixtures from their surroundings.
- Explain uses of common mixtures in daily life.
- Explain why air is considered as a mixture of gases.
- Identify the sources of carbon dioxide and how its level can be maintained in nature.
- Separate mixtures using a variety of techniques.
- Choose a technique to separate and identify different components in dyes.
- Demonstrate with an experiment to separate soluble solids from mixtures.
- Use safety measures to conduct science experiments.

Atoms and Molecules

We see many things around us. Some are big and some are small. All things are made of **matter**.

Matter is made of atoms. **Atom** is the smallest particle of matter which takes part in a chemical reaction. We cannot see atoms because they are so small. Atoms except noble gases cannot exist independently.

Two or more atoms can join together to form larger particles of matter called **molecules**. Molecules can exist independently. Sometimes a molecule has the same kind of atoms but, sometimes, different atoms combine to form a molecule. For example, one molecule of oxygen gas is made of two similar oxygen atoms (Fig. 5.1). A water molecule has three atoms, i.e. one oxygen atom and two hydrogen atoms (Fig.5.2).

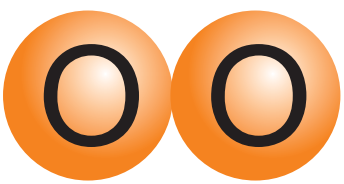


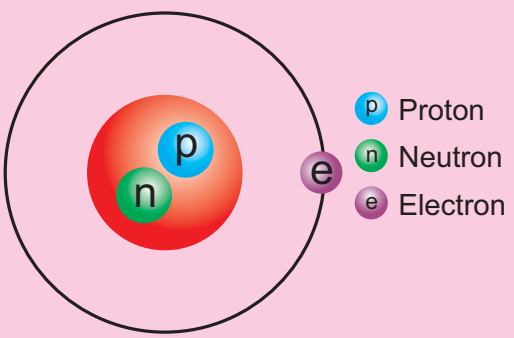
Fig.5.1: Oxygen molecule (O_2)

Fig.5.2: Water molecule (H_2O)

Fig.5.3: Graphite used in lead pencils is made of carbon atoms.

Do you know?

The word 'atom' means 'indivisible'. But now the scientists have discovered that an atom is divisible. Atoms are made of the fundamental particles called electrons, protons and neutrons. These particles are even smaller than the atoms.



Take plasticine or clay of different colours. Make balls of different sizes. Use these balls to make models of oxygen and water molecules.

Elements

The matter consisting of only one kind of atoms is called an **element**. Gold, silver and copper are the examples of elements.

If we take a piece of coal which is carbon and break it into very small pieces. We will find that its very small piece is also coal (carbon). Elements cannot be broken down into further simpler forms by ordinary chemical processes.


sulfur powder


carbon (coal)


iron


gold

Fig.5.4: Every element consists of one kind of atoms.

There are 109 elements known to scientists. Around 92 elements are naturally found. Other elements are made by scientists. Elements exist in all three states of matter. For example iron is a solid element. Mercury is a liquid element and oxygen is an element in gaseous state.

Some Common Elements and their Symbols

In the beginning, each element was written in its full name. A short way to write the names of elements was developed. Each element is given a symbol. A **symbol** is the abbreviated name of an element. The symbol consists of one or two letters taken from the English or Latin name of the element.

'H' is the symbol of hydrogen.'Na' is the symbol of sodium whose Latin name is *natrium*.

Table 5.1: Some common elements and their symbols

Element	Symbol	Element	Symbol
Aluminium	Al	Iron (Ferrum)	Fe
Calcium	Ca	Mercury (Hydrargyrum)	Hg
Carbon	C	Nitrogen	N
Chlorine	Cl	Oxygen	O
Copper (Cuprum)	Cu	Phosphorous	P
Gold (Aurum)	Au	Silver (Argentum)	Ag
Hydrogen	H	Sulphur	S
Iodine	I	Sodium (Natrium)	Na

Classification of Elements

Scientists classify elements into two main groups, i.e. metals and non-metals.

Metals

About 70 percent elements are metals. All metals have similar properties. Most of the metals are shiny or gray solids and they can be moulded or shaped by heating and pressing. Metals are also good conductors of heat and electricity as they allow them to pass through. Some common metals are given in the table 5.2.

Table 5.2: Common Metals

Aluminium (Al)	Iron (Fe)	Silver (Ag)
Calcium (Ca)	Lead (Pb)	Sodium (Na)
Copper (Cu)	Mercury (Hg)	Zinc (Zn)

Fig.5.5: Metal elements are used to make many objects.

Non-metals

The elements other than metals are called non-metals. They have different properties from metals. Non-metals can be solids, liquids or gases. Solid non-metals are brittle and you cannot mould or shape them. Most of the non-metals do not allow electricity and heat to pass through them. They are non-conductors.

A few non-metals are given in the table 5.3.

Table 5.3: Common Non-metals

Carbon (C)	Hydrogen (H)	Oxygen (O)
Chlorine (Cl)	Nitrogen (N)	Sulphur (S)

Uses of Some Common Elements

We can relate the physical properties of elements to their uses.

Physical Properties and uses of Metals

Metals are widely used in our everyday life due to their physical properties.

I. State

Most metals are found in solid state. However, mercury (Hg) is found in liquid state. Mercury is filled in thermometers to measure temperature.

ii. Hardness

Most metals are hard solids. For example, iron is used to make steel. The steel is then used for making rails, bridges, ships, girders, surgical instruments and utensils.

iii. Lustre

Freshly cut metals have brilliant shine, called lustre. For example, aluminium is used for making utensils and picture frames due to its lustre. Gold and silver are used to make ornaments because of their shine.

iv. Melting and Boiling Points

Metals have high melting and boiling points. Due to this property iron, copper and aluminium are used to make kitchen utensils.

v. Strength and Malleability

Metals are used to make sheets, wires and springs due to their property of strength and malleability.

vi. Conductivity

Metals like copper and aluminum are used in electrical wiring. They have the property to allow the electricity to pass through them. This property is called conductivity.

Alloys

An interesting property of metals is the ability to form alloys. An alloy contains more than one metals. German silver is an alloy of copper, zinc and nickle. It is used in jewellery. Brass is the alloy of copper and zinc which is used to make pipes, hose nozzles and jewellery.

Physical Properties and Uses of Common Non-metals

Non-metals are found in solid, liquid and gaseous states. Most non-metals are not hard. Most non-metals have no shine or luster. They have low melting and boiling points. Most non-metals are bad conductors of electricity. However, graphite is a good conductor of electricity. Non-metals are widely used in our daily life.

1. Air contains several gases, which are non-metal elements.
2. Welders use flame of hydrogen and oxygen for cutting and welding metals.
3. Hydrogen and nitrogen gases are used in the manufacture of urea (fertilizer).
4. Banaspati ghee is manufactured by the use of hydrogen and vegetable oil.
5. Phosphorous is used in match industry.
6. Oxygen gas is used in hospitals.
7. Carbon as diamond is used in jewellery.
8. Graphite (carbon) is used by mixing with clay in pencils.

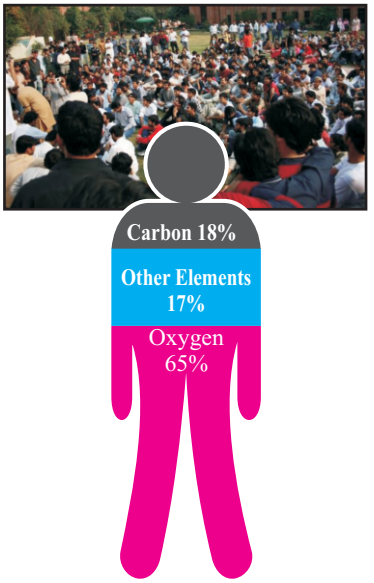


Fig.5.6: People are made of mostly non-metals.

Do you know?

Diamond (carbon) is a non-metal, but it is the hardest matter on the Earth. It is shiny and is used in jewellery. It is also used to cut glass.

Take different objects, such as metal wire, a metal key, a ruler, a glass slide, an eraser, etc. Make a circuit with a battery, switch and bulb. Pick up the objects one at a time, attach them in the circuit. If the bulb lights up then it is a metal, if it doesn't then the object is a non-metal.

Compounds and Mixtures

Many things on the Earth are not elements. Some of them are compounds and some are mixtures.

Compounds

When two or more elements combine chemically in a fixed ratio, a **compound** is formed. For example, water is the compound made of the elements hydrogen and oxygen.

Hydrogen + Oxygen ⟶ Water

There are 109 known elements but there are thousands of compounds.

Elements in a compound cannot be separated easily. Properties of elements change when they are combined as compounds.

In case of water, hydrogen and oxygen are colourless gases. They have no smell or taste. Hydrogen will burn very quickly in oxygen. Both of these gases combine to form water which is a compound. We can see and taste it.

Fig. 5.7: Some common compounds of everyday use

Mixtures

When two or more substances are mixed in such a way that no chemical change takes place, the combination is called a **mixture**.

Parts of a mixture can be separated easily because they are not chemically combined. All the parts in a mixture keep their own properties. For example, salad in the bowl is a mixture of different fruits and vegetables. You can taste them. How could you separate iron buttons from a mixture of different buttons?

A mixture may be homogenous or heterogeneous. A **homogenous** mixture has uniform appearance throughout. For example, a mixture of sugar or salt dissolved in water. A **heterogenous** mixture does not have uniform appearance throughout. This mixture is made of different parts. For example, a mixture of oil and water.

Fig.5.8: Some examples of mixtures

Take a glass of water, add some amount of table salt in it and stir it well. Where does the salt go? Salt is mixed in the water. Can you separate the salt and water again?

- Take a mixture of sulphur and iron filings in a china dish.
- Move a bar magnet in this mixture. What did you observe?
- Now heat the mixture of sulphur and iron filings. It will change into a black mass.
- Move the bar magnet in this black mass. What did you observe?

Is the black mass a compound or a mixture?

Uses of Compounds and Mixtures

We use a number of compounds and mixtures in our everyday life.

Water is used in homes, in industries and in agriculture. Without water life is impossible.

Carbon dioxide is a compound of carbon and oxygen. Plants use it to make food. It is used to manufacture urea (fertilizer) and the bread. It is also filled in soda bottles.

Sodium chloride is commonly known as table salt. It is the compound of sodium and chlorine elements. People use it to preserve fish and pickles. We add it to our food to make it salty. It is also used to manufacture caustic soda and washing soda.

Fig.5.9: Fire extinguisher uses carbon dioxide to put out the fire.

Sherbat is a mixture of sugar, water, table salt and lemon, etc. We use it in hot summer days. **Salad** is a mixture of different vegetables as onion, carrot, radish, beet, cucumber, tomato and cabbage, etc. **Ice cream** is a mixture of milk, sugar and flavour. **Milk** is also a mixture of water, fats, proteins and carbohydrates. **Tincture of iodine** is a mixture of iodine and alcohol. We apply it on a cut to kill the germs.

Fig.5.10: Ice cream is a mixture.

Do you know?

The sea is the world's largest mixture. It covers about 70 percent of the Earth's surface. Water, sodium chloride (table salt) and many other salts are present in the sea water.

Air as a Mixture of Gases

Air is a mixture of gases. The largest component of air is nitrogen gas which is about 78 percent. 21 percent of air is the oxygen gas. Many other gases like carbon dioxide, helium, etc. form remaining one percent of air. Each gas in the air keeps its individual identity and can be separated.

Besides gases, air also contains water vapour, particles of dust, smoke and pollen grains. Which components of air are elements and which are compounds?

Level of Carbon dioxide in Air

The amount of carbon dioxide (CO_2) in the air is 0.03 to 0.04 percent. All green plants use this carbon dioxide to make their food during photosynthesis. Is it not strange that its level in the air is maintained at the above given ratio all the time? Nature has managed the level of carbon dioxide by different methods. All organisms evolve this gas during respiration. By the burning of wood, coal and oil, carbon dioxide is produced.

Separating Mixtures

We have learnt that the components of a mixture can be easily separated. This separation has important applications in our everyday life.

1. Filtration

Filtration is a method in which we use a filter paper or filter cloth to separate insoluble solids of a mixture from a liquid.

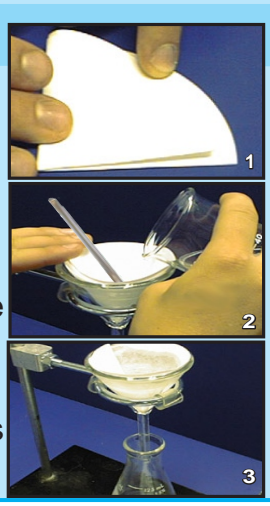
We use strainer for separating tea leaves from tea. This is also a process of filtration. In a water filtration plant, filtration is used to separate solid impurities from dirty water.

You will need:] filter paper] glass funnel] glass rod] iron stand] beakers] muddy water

Procedure

1. Take a filter paper and fold it as shown in the figure 1.
2. Fit the filter paper in a wet glass funnel.
3. Now take some muddy water in a beaker and pour it on the glass rod in the funnel.
4. The water passes through the filter paper into the beaker.

_ The mud is kept back by the filter paper. The process is called **filtration**.



Do you know?

- The hair and mucus in our nose help in the filtration of air before entering the lungs.
- Our kidneys filter the blood and separate waste materials in the form of urine.
- Water filters use the process of filtration to clean the tap water.

2. Sublimation

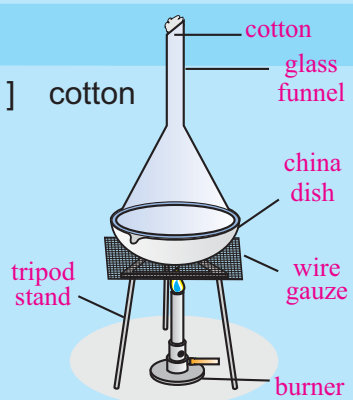
The process in which a solid on heating, directly changes into gas or vapour state is called **sublimation**. We can use this process to separate the two components of a mixture if one component has the property of sublime.

Put a few balls of naphthalene in your cupboard with clothes. You will not find these balls after some months. Where do the balls go? It is also interesting that on cooling, the vapours again return to solid.

Solid $\underset{\text{cooling}}{\overset{\text{heating}}{\rightleftharpoons}}$ Vapours

Iodine, ammonium chloride (noshader), camphor (kafoor) and naphthalene have the property of sublime.

You will need:] a china dish] a glass funnel] cotton] a tripod stand] a burner or spirit lamp] mixture of ammonium chloride (noshader) and sand



Procedure

1. Take a china dish and put some mixture of ammonium chloride and sand in it.
2. Invert a glass funnel over the china dish and close the end of the funnel with a cotton swab.
3. Set the apparatus as shown in the figure.
4. Heat the mixture.

_ After some time you will see white powder on the inner walls of the funnel.
_ Sand remains in the china dish.

Things to think: Which one has the property of sublime, noshader or sand?

3. Distillation

Mixtures can be separated with another method called distillation if the components of the mixture have different boiling points. **Distillation** is the method by which two or more liquids in solution are separated by boiling off the liquid with the lower boiling point and condensing it in another container.

Doctors use distilled water for injections. In some countries like Kuwait and Saudi Arabia, sea water is passed through the process of distillation to get drinking water.

Crude oil is a mixture of different chemicals such as petrol, tar, oil, dissolved gases and kerosene. In an oil refinery the method of distillation is used to separate components of crude oil.

Fig.5.11: The process of distillation is used in an oil refinery to get petrol.

You will need:] large bowl] small glass] tape] plastic sheet] small stone] water] salt

Procedure

1. Take some mixture of salt and water in a large bowl.
2. Take an empty small glass and put it in the bowl. The top of the glass should be higher than the saltwater.
3. Cover the top of the bowl with a plastic sheet (use tape).
4. Put a small stone right in the center of the plastic sheet, over the glass. The stone will weigh the plastic down and help you to collect the distilled water.
5. Put the apparatus in bright sunshine for a few hours to distill water from the solution.
6. Take the plastic sheet off and taste the water that's collected in the glass. Do you think it's salty or fresh?

Can you explain the process of separating water from the mixture of salt and water?

4. Paper Chromatography

Dyes and inks are mixed to make the colours for food, clothes and pens. We can use a method called chromatography to find if the colour in the ink of a pen is a pure dye or a mixture of dyes.

Chromatography is the separation of coloured chemicals. It works because some components of a mixture are more soluble than others.

In paper chromatography special paper is used to separate the coloured components in a mixture. Chromatography only works for soluble dyes, like that in food

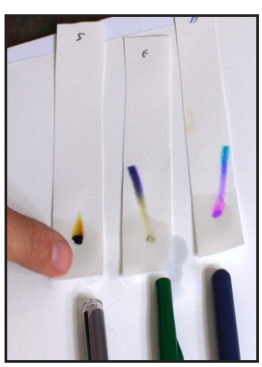
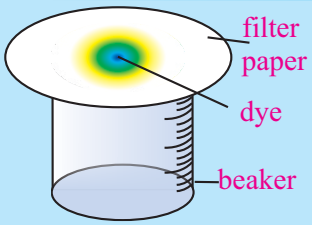


Fig.5.12: Chromatography works to separate different dyes in inks.

and pen, not the dyes in clothes. The most soluble dyes move faster on a filter paper than less soluble dyes (Fig. 5.12).

You will need:] a beaker] a medicine dropper] a filter paper] solution of a dye or ink



Procedure

1. Place a filter paper on the beaker.
2. Put a drop of ink in the middle of the filter paper.

Soon you will see different bands of colour on the filter paper. Each band shows the presence of a different component of the solution.

Things to think: Why do bands of colours appear on the filter paper?

Safety in Science

You need to be careful when doing science activities. Here are some safety tips to remember.

- Listen to your teacher's instructions carefully.
- Read each activity carefully.
- Never taste or smell materials unless your teacher tells you to do.
- Handle scissors and other sharp things carefully.
- Keep your work place neat and clean.
- Tell your teacher at once if you see something that looks unsafe.
- Wash your hands well after each activity.

1. Atoms are the building blocks of matter.
2. The simplest form of matter is called element.
3. Symbols are used to represent elements.
4. Elements are classified into: i. metals ii. non-metals
5. We use metals and non-metals according to their physical properties.
6. Elements combine chemically to form compounds.
7. When substances mix without showing chemical change, a mixture is formed.
8. Air is a mixture of gases.
9. Filtration, sublimation, distillation and paper chromatography are the methods of separating components of mixtures.

1. Write proper term/word against each statement.

i. Building blocks of matter _____

ii. The matter consisting of only one kind of atoms _____

iii. The process of separating components of a mixture having different boiling points _____

iv. The separation of coloured chemicals _____

v. A solid changes into vapours without becoming a liquid _____

2. Encircle the letter of the best answer.

i. When elements are joined chemically in a compound, they:

(a) loose their original properties (b) keep their original properties

(c) become a mixture (d) become another element

ii. Which of the following does not describe elements?

(a) all the particles are alike (b) can join together to form compounds

(c) can be broken down into simpler substances

(d) have particular properties

iii. Which substance is a compound?

(a) carbon (b) chlorine

(c) sodium chloride (d) sodium

iv. Which process can be used to separate salt from the mixture of salt and water?

(a) filtration (b) sublimation

(c) paper chromatography (d) distillation

v. How can you see the colours of chemicals present in bright-coloured chocolate beans?

(a) by distillation (b) by sublimation

(c) by paper chromatography (d) by filtration

3. Answer the following questions in detail.

i. Relate physical properties of metal elements with their uses.

ii. Define and explain compounds.

iii. What do you know about sublimation and distillation?

iv. Define paper chromatography and explain it with the help of an activity.

v. Write symbols of the following elements:

potassium nitrogen sodium gold mercury silver

4. Extend your thinking.

i. Why is water said to be a compound instead of an element?

ii. Explain why salt cannot be removed from a salt-water mixture by pouring the

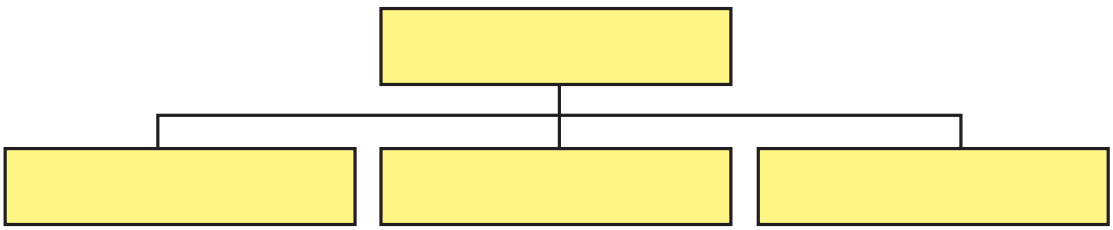
mixture through a filter paper.

iii. Describe a procedure to separate a mixture of salt, finely ground pepper and pebbles.

iv. If we try to separate the parts of a material and cannot, does this means that the material is an element? Explain why.

5. Concept Map

Complete the concept map using following words.
element, substance, mixture, compound



1. Cut a strip of paper from a filter paper. Use tape to wrap one end around a pencil so that the other end will just touch the bottom of a clear plastic cup. Using a water soluble black marker, make a small dot in the center of the strip. Pour water in the cup. Keep the pencil with filter paper strip carefully on the cup so that the strip end just dip in the water. What happened as the filter paper absorbed the water? What colours were mixed to make black ink?

2. Can you identify baking soda and powdered sugar? Put some amount of each compound in two clear plastic cups. Pour some amount of vinegar to each cup. Baking soda reacts with vinegar, while powdered sugar does not. Which of these compounds is baking soda and which is sugar?

Alloy formation is an interesting property of metals. An alloy is a solid solution of metals or non-metals dissolved in metals. Brass is an alloy of the metal zinc dissolved in copper. Steel is an alloy made of the non-metal carbon and other elements dissolved in iron. Some people use this property of metals to earn unlawful money. Investigate the people who use this property of metals illegally.

Computer Links

- http://www.docbrown.info/page01/ElCpdMix/EleCmdMix.htm
- http://www.hometrainingtools.com/mixtures-compounds-science-explorations-newsletter/a/1214/