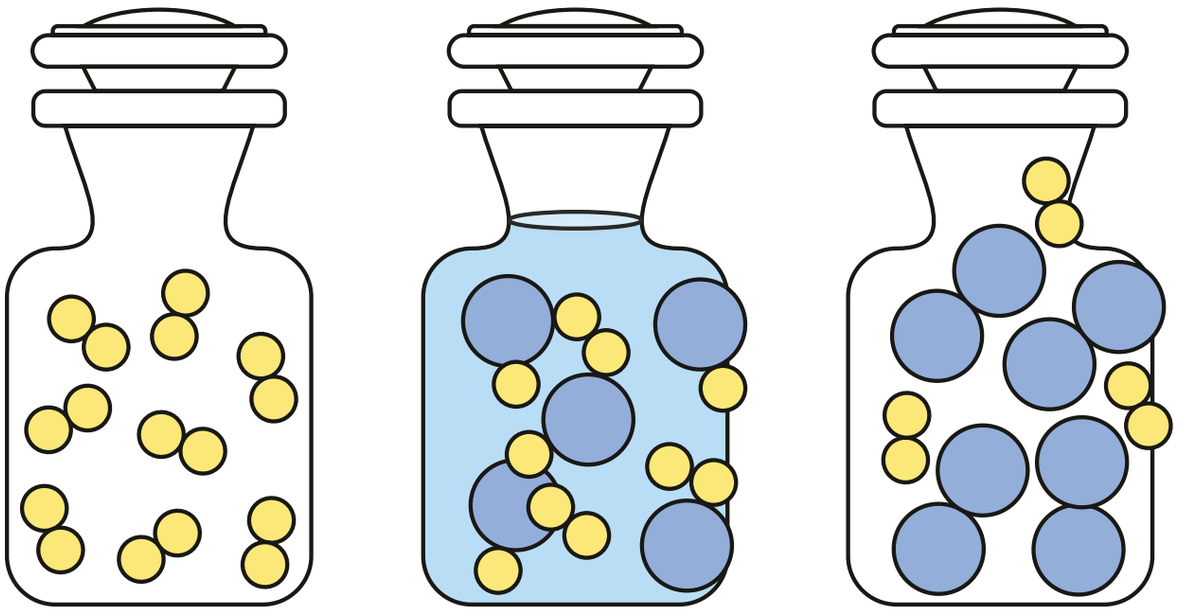
Unit 3

Matter Around Us



Element (Hydrogen) **Compound (Water)** **Mixture (Hydrogen & Oxygen)**

Learning Objectives

After studying this unit, students will be able to:

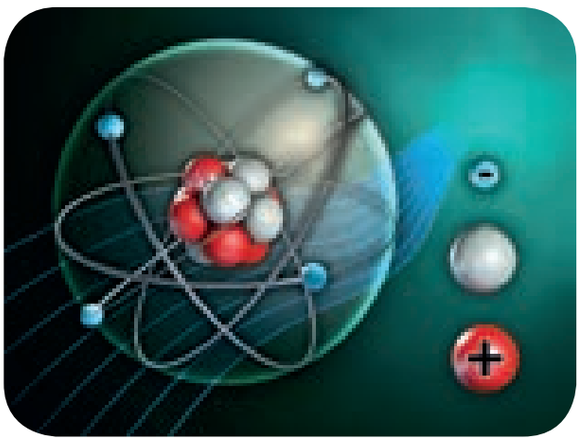
- know about the molecules of elements and compounds.
- write the symbols of common elements.
- calculate the atomicity of commonly used elements.
- know about the occurrence of elements and compounds in nature and human body / air.
- understand the effects of temperature on solid, liquid and gas.

Introduction

We know that everything that occupies space and has mass is called matter. Do you know what is matter is composed of? We have studied earlier that matter is composed of tiny little particles, which cannot be seen with naked eye. That particle is called atom. In this lesson, we will study about atoms, molecules, elements, compounds, chemical formulae and atomicity.

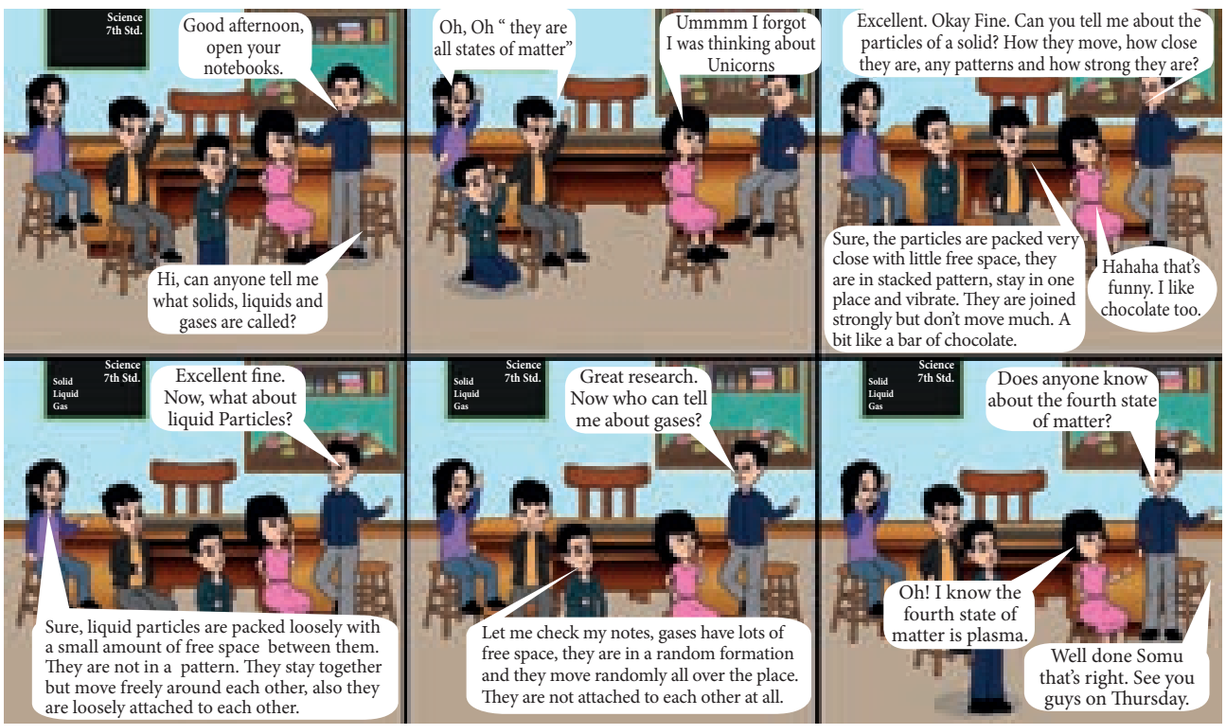
3.1 Atoms

Graphite lead used in pencil is made up of an element called carbon. We can break graphite into smaller and smaller pieces. If we have a finer knife, we can break it even smaller. If we keep cutting the minuscule graphite into smaller and smaller particle, we will reach a point where we get the smallest constituent of graphite - carbon atom. If we break the carbon atom apart, the properties of carbon are exhibited. The smallest unit of an element that exhibits the properties of that element is called as 'atom'. All the matter is composed of tiny particles called atom. Water, rice and everything we see around is made up of atoms. An atom is the basic unit of a matter.



Structure of an atom

Even with the best of optical microscope we cannot see atoms. However, there are advanced instruments that help us to imagine the atoms on the surface of a material. For example, the following figure shows the image of the surface of silicon.



Surface of Silicon

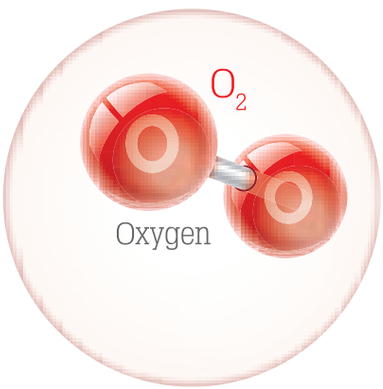
DO YOU KNOW?

The most abundant atom in the universe is the hydrogen atom. Nearly 74% of the atoms in the universe are hydrogen atoms. However, three most abundant atoms on the Earth are iron, oxygen and silicon.

3.2 Molecules

When an atom combines with another atom (or atoms) and forms a compound, it is called as molecule. *A molecule is made up of two or more atoms chemically combined.*

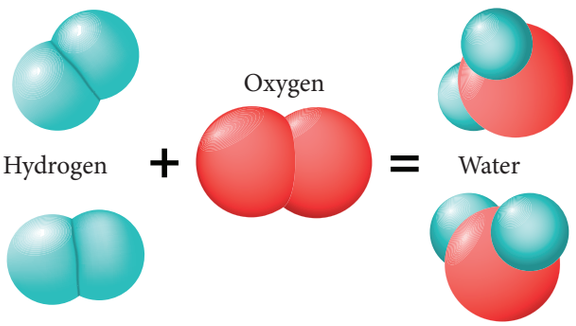
Oxygen gas in the air that we breathe is made up of two oxygen atoms chemically combined.



Ozone is a substance that is made up of three oxygen atoms chemically combined.

An atom of oxygen (O) and two atoms of hydrogen (H) combine to form a molecule of water (H_2O).

$$2H_2 + O_2 = 2H_2O$$



Formation of water molecule

Molecules exhibit the properties of matter and also have individual existence. A molecule can be formed by the same or different kinds of atoms.

Molecules can be classified as below.

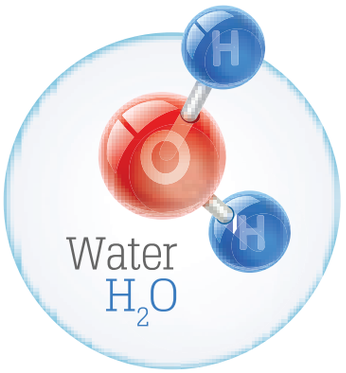
- A molecule which contains only one atom is called monatomic molecule (Inert gases).
- A molecule which contains two atoms is called diatomic molecule (Oxygen, Nitric oxide, Hydrogen, etc.).
- A molecule containing three atoms is called a triatomic molecule (Ozone, Sulphur dioxide, Carbon dioxide, etc.).
- A molecule containing more than three atoms is known as polyatomic molecule (Phosphate, Sulphur, etc.).

3.2.1 Molecules of Elements

A molecule of an element consists of fixed number of one types of atom chemically combined. Table 3.1 shows that gases are made up of two atoms of the same element.

3.2.2 Molecules of Compounds

Molecule of a compound consists of a fixed number of different types of atoms chemically combined. For example, let us look at the model of a water molecule below. Each molecule of water consists of one oxygen atom and two hydrogen atoms. The ratio of oxygen and hydrogen atoms remains fixed whether water is in liquid, solid or gaseous state. This principle applies to the molecules of all compounds. Compounds with different atoms are given in Table 3.2.



Model of molecular water

Bismuth in diarrhea medicine

Bismuth is an element that occurs naturally. It is combined with other elements to make medicine for treating diarrhea.

Table 3.1 Compounds with same atoms

Molecule	Chlorine Gas	Oxygen Gas	Nitrogen Gas
Molecule Diagram	Cl Cl	O O	N N
Molecule Model (Ball-and-Stick)	 Chlorine Molecule	 Oxygen Molecule	 Nitrogen Molecule

Table 3.2 Compounds with different atoms

Molecule	Carbon dioxide	Ammonia	Hydrogen Chloride
Molecule Diagram	O C O	H N H H	H Cl
Molecule Model (Ball-and-Stick)	 Carbon-dioxide Molecule	 Ammonia Molecule	 Hydrogen Chloride

3.3 Elements

Matter is classified into two broad categories, namely, pure substances and mixtures. Pure substances are further divided into two categories as elements and compounds.

Matter in its simplest form is called an element. We are using many elements in our daily life. The common salt consists of two elements, sodium and chlorine. Water consists of hydrogen and oxygen. Magnesium and phosphorus are used for making crackers. Sulphur is used as manure in agriculture. Gallium is used for making mobile phones and silicon is used for making computer chips.

There are 118 known elements till date. Out of these, 94 elements occur naturally while 24 elements are synthesised artificially in the laboratory.

3.3.1 Classification of Elements

We can classify the elements broadly into metals, non-metals and metalloids based on their chemical properties.

Robert Boyle is the first scientist who used the term element. He is the early proponent of the elemental nature of matter and the nature of vacuum. He is known best for Boyle's Law.

Metals

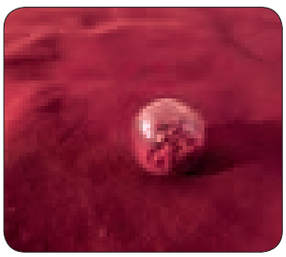
We have tools, utensils and jewellery made of silver, copper, iron, gold, aluminium, etc. By hammering or rolling we can deform these materials into various shapes. Such elements that are malleable (a material may be flattened into thin sheets or various shapes) are called as metals.

Metals are generally hard and shiny elements. Sodium is one of the exceptions as it is soft. All metals, except mercury are solids at room temperature. Mercury is the only metal that is liquid at room temperature. Metals are malleable, can be bent or beaten into sheets. They can be drawn into wires. They are good conductors of heat and electricity. Copper, lead, tin, nickel, iron, zinc, gold, magnesium and calcium are examples of metals.

Metals

Non-metals

Non-metals are generally dull and soft. However, diamond is shiny and also the hardest natural substance on earth. Non-metals can be gases, solids and liquids. Non-metals such as oxygen, hydrogen and chlorine are gases at room temperature. Carbon, iodine, sulphur and phosphorus are solids at room temperature. Bromine is the only non-metal that is liquid at room temperature. Non-metals are poor conductors of heat and electricity. However, graphite (a form of the non-metal carbon) is a good conductor of electricity.


Phosphorus


Sulpher

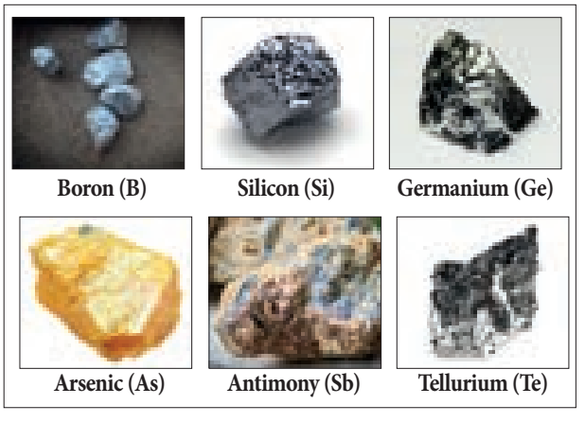
Non - metals

Table 3.3 Difference between metals and non-metals

Metals	Non-Metals
Metals are lustrous. They have a shiny surface.	Non metals are non lustrous. They have non- shiny surface.
Metals are generally hard.	Non-metals are generally soft.
Most metals can be bent, beaten into sheets and they can be drawn into wires.	Non-metals can not be bent, beaten into sheets and they can not be drawn into wires.
Most metals are good conductors of electricity.	Non-metals are bad conductors of electricity.
Most metals are good conductors of heat.	Non-metals are bad conductors of heat.
Most metals make ringing sound when struck. Hence, they are used to make objects like bells.	Non-metals does not make any sound when they are struck.

Metalloids

Metalloids exhibit the properties of both metals and non metals. Silicon, arsenic, antimony, and boron are some examples of metalloids.



Metalloids

3.3.2 Symbol of an element

A symbol is an abbreviation or short representation of a chemical element. There is a unique symbol for each element. It represents one atom of the element. The symbol is usually derived from the name of the element, which is either in English or Latin. These symbols are accepted by the International Union of Pure and Applied Chemistry (IUPAC).

Dalton was the first scientist to use the symbols for elements in a very specific sense. When he used a symbol for an element he also meant a definite quantity of that element, that is, one atom of that element. Berzelius suggested that the symbols of elements can be written as one or two letters of the name of the element.

The following rules are followed while assigning symbol to an element.

DO YOU KNOW?

In the beginning, the names of elements were derived from the name of the place where they were found for the first time. For example, the name copper was taken from Cyprus. Some names were taken from specific colours. For example, gold was taken from the English word meaning yellow. Now-a-days, IUPAC approves names of elements. Many of the symbols are the first one or two letters of the element's name in English. The first letter of a symbol is always written as a capital letter (uppercase) and the second letter as a small letter (lowercase).

ACTIVITY 1

Find out the symbols of the elements with the help of your teacher.

Elements	Symbol
Gold	
Silver	
Copper	
Iron	
Nitrogen	
Oxygen	
Aluminium	
Calcium	
Phosphorus	
Magnesium	
Potassium	
Sodium	

- Chemical symbols usually consist of one or two letters.
- The symbols of most elements correspond to the first letter (which is capitalized) of their English name. For example, the symbol for oxygen is O and that for hydrogen is H. You will study about symbols in details in standard 8.

3.3.3 Elements in human Body

Nearly 99% of the mass of our human body consists of just six chemical elements namely, oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus. Another five elements make up most of the least percentage. They are potassium, sulphur, sodium, chlorine, and magnesium.

3.3.4 Elements in air

Air is a mixture of gases. The molecules of two different elements, nitrogen and oxygen, make up about 99% of the air. The rest includes small amounts of argon and carbon dioxide. Other gases such as neon, helium, and methane are present in trace amounts. Oxygen is the life-giving element in the air.

3.4 Compounds

A compound is a pure substance that is formed when the atoms of two or more elements combine chemically in definite proportions.

Compounds exhibit properties that are entirely different from the properties of their constituent elements. For example, the atoms of the elements hydrogen and oxygen combine chemically in a fixed ratio to form the compound water. However, water does not have the same properties of hydrogen and oxygen. For example, at room temperature water exists as liquid while hydrogen and oxygen exist as gases. Also, oxygen supports fire whereas water is used as a fire extinguisher.

Similarly, common salt (Sodium chloride) is a compound made up of elements sodium and chlorine. It is used in our food, whereas sodium and chlorine are poisonous, and both are unsafe for consumption.

Sodium is a highly reactive solid at room temperature . It burns vigorously when in contact with water

+

Chlorine is yellowish green poisonous gas at room temperature

→

Sodium Chloride (Used for cooking)

Chalk (Calcium, Carbon and Oxygen)

Sugar (Carbon, Hydrogen and Oxygen)

3.4.1 Properties of Compounds

- A compound is formed only when the constituent elements combine in a fixed proportion.
- The properties of a compound are different from those of its constituent elements.
- A compound cannot be broken down by physical methods. This is because a compound is made up of different elements that are chemically combined. Sodium chloride cannot be separated by physical methods such as filtration.
- A compound can be separated into its constituent elements by chemical methods only.

ACTIVITY 2

Complete the following table.

Compound	Constituent Elements
Water	
Salt (Sodium chloride)	
Sodium carbonate	
Baking soda (sodium bicarbonate)	
Sugar	
Calcium oxide	
Calcium hydroxide	
Sodium hydroxide	
Potassium hydroxide	

ACTIVITY 3

Complete the following table.

Formula	No. of different elements	Name of Elements
H_2O	H – 2 O – 1	Hydrogen, Oxygen
NaCl		
$C_6H_{12}O_6$		
NaOH		

Table 3.4 Difference between an element and a compound

Elements	Compounds
An element is the simplest substance.	A compound is a chemical substance formed by the combination of two or more elements.
Elements combine to form compounds.	Compounds can be split into elements.
Atoms are the fundamental particles of an element.	Molecules are the fundamental particles of a compound.

3.5 Chemical Formulae

Often we write water as H_2O. This is the chemical formula for water molecule. This means that each molecule of water has two hydrogen atoms combined with one oxygen atom. A chemical formula is a symbolic representation of one molecule of an element or a compound. It provides information about the elements present in the molecule and the number of atoms of each element. In H_2O, small number beside the 'H' is called subscript. It tells us the number of atoms of that element present in the molecule. Hence, there are two hydrogen atoms in water molecule. There is no number of besides 'O'. It means that there is only one atom of that element present in the molecule. Hence, there is 1 oxygen atom in a water molecule. Can you guess the types of atoms and number of each of the atoms in sodium chloride? Which is the chemical formula for cooking salt?

Here are some examples of chemical formula.

Sodium Chloride (Nacl) : 1 atom of Sodium and 1 atom of chlorine

Ammonia (NH_3) : 1atom of Nitrogen and 3 atoms of Hydrogen

Glucose ($C_6H_{12}O_6$) : 6 Carbon atoms, 12 Hydrogen atoms and 6 Oxygen atoms

The chemical formula tells us the types of atoms and the number of each type of atom in one molecule of substance.

Table 3.5 Common compounds and their chemical formula

Names	Formula
Water	H_2O
Glucose	$C_6H_{12}O_6$
Salt	NaCl
Ethanol	C_2H_5OH
Ammonia	NH_3
Sulphuric Acid	H_2SO_4
Methane	CH_4
Sucrose	$C_{12}H_{22}O_{11}$

3.6 Atomicity

In chemistry, atomicity implies the total number of atoms present in one molecule of an element, compound or a substance. Let us see how to calculate the atomicity of elements. For example, oxygen exists as a diatomic molecule. It means that a molecule of oxygen contains two atoms hence its atomicity is 2.

$$O + O \longrightarrow O_2$$

Oxygen atom + Oxygen atom ⟶ Oxygen Molecule

Similarly a phosphorus molecule (P_4) contains 4 atoms and a sulphur molecule (S_8) contains 8 sulphur atoms. Hence, their atomicity is 4 and 8 respectively.

For molecule containing more than one types of atoms, simply count the number of each atom and that would be its atomicity. For example, one molecule of sulphuric acid (H_2SO_4) consists of 2 hydrogen atom, 1 sulphur atom and 4 oxygen atoms. Hence, its atomicity is 7(2+1+4).

One molecule of water (H_2O) contains two atoms of hydrogen and one atom of oxygen. Thus, the atomicity of water is three.

Table 3.6 Atomicity of some elements

Element	Atomicity	Elements	Atomicity
H	2	F	2
He	1	Ne	1
Li	1	Na	1
Be	1	Mg	**1**
N	2	P	4
O	2	S	8

ACTIVITY 4

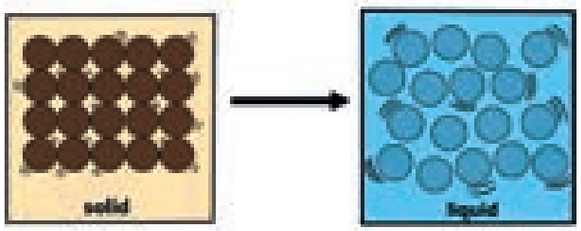
Write down the atomicity of the following elements and compounds

Elements / Compounds	Atomicity
Cl	
Na	
K	
Ca	
H_2O	
Nacl	

3.7 Effect of temperature on Solid, Liquid and Gas

In solids, particles are arranged very closely. When solids are heated, the particles in them gain energy and vibrate vigorously. They move slightly further apart from one another. This causes the volume of matter to increase. This process is called expansion. How it happens?

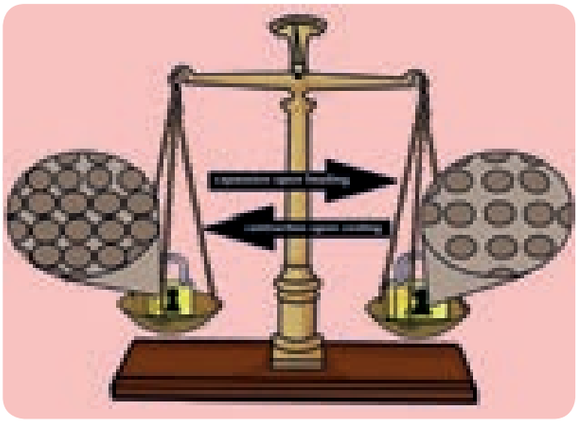
The matter begins to expand when heated and the volume increases due to the increase in the distance between the particles. But, the size of the particles remains same.



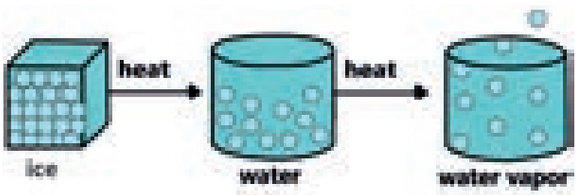
DO YOU KNOW?

How do hot-air balloons float? When air inside the hot air balloon is heated with a burner, it expands. The expansion causes the density of the air inside the balloon to decrease. Hence, the air inside the balloon has a lower density than the air outside the balloon. This difference in density allows the hot-air balloon to float.

During heating or expansion, the mass of matter does not change. Although the volume of the matter changes, the size and number of the particles of matter do not change. Hence, during heating, the mass of matter is conserved. For example, in an iron lock the distance between the iron particles increases when they gain enough heat. However, the number of iron particles does not change. Hence, the mass of the iron lock is conserved.



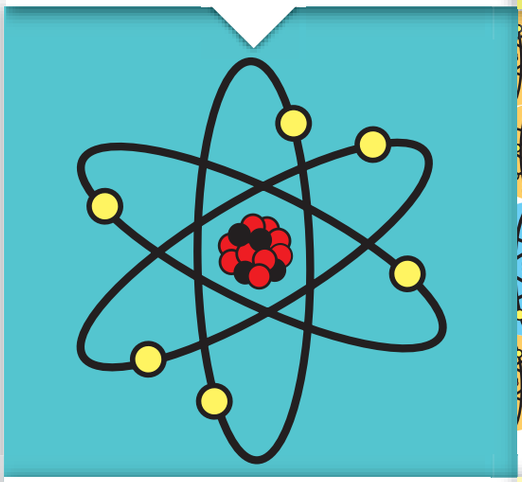
The melting of ice is an example for change of states of matter. The change in the states of matter occurs during melting, boiling and freezing and condensation. When the particles possess enough energy, they overcome the strong forces of attraction between one another. They break free from one another and move randomly. For example, when solid ice is heated to 0^0C, it melts to become liquid water. In the same way, when liquid water is heated to 100^0C, it boils to become steam.



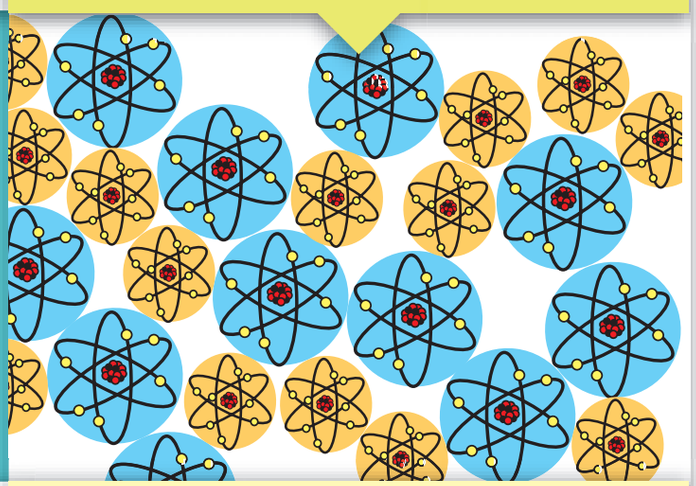
1. Solid
When solid is heated, the particles gain energy and vibrate more vigorously
2. Liquid
When the melting point is reached melting occurs. The solid changes to its liquid state.
When a liquid is heated the particles gain energy and vibrate more vigorously.
3. Gas
Boiling occurs when the boiling point is reached. The liquid changes to its gaseous state.

Configuration of Matter

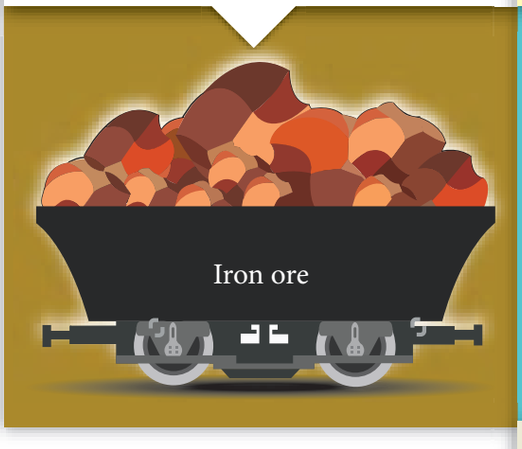
ATOM
Smallest particle of an Element



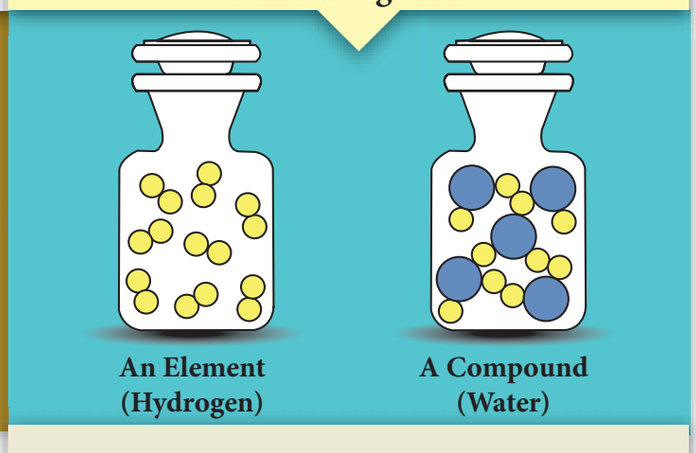
MOLECULE
Atoms makes molecules



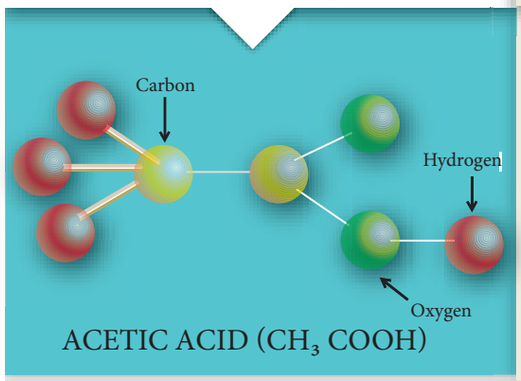
ELEMENT
Chemically simplest substance which cannot be broken down



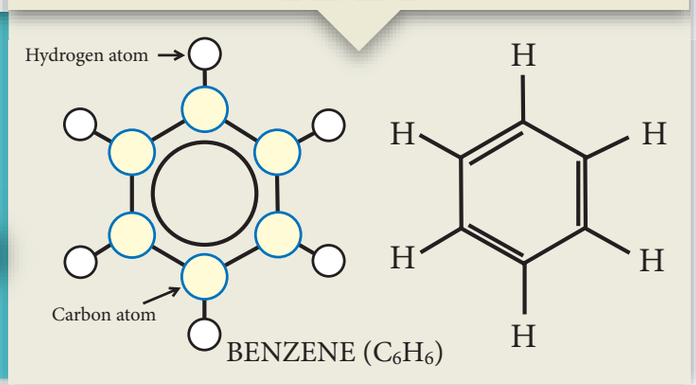
COMPOUND
Two or more elements which are chemically bonded together



CHEMICAL FORMULA
Tells the number of atoms of an element in a compound



CHEMICAL SYMBOL
Short representation of an Element



Points to Remember

- ❖ Elements are the simplest forms of pure substances.
- ❖ Molecules of an element consist of a fixed number of one type of atom.
- ❖ Molecules of a compound consist of a fixed number of different types of atom.
- ❖ The molecules of the elements nitrogen and oxygen make up 99 percent of the air.
- ❖ An atom is the smallest particle of an element.
- ❖ The particulate nature of matter can be used to explain heating effect of solid, liquid and gas.
- ❖ The mass of the matter remains same during expansion.
- ❖ A molecule is made up of two or more atoms chemically combined.
- ❖ We can represent a molecule using chemical formula.

Evaluation

I. Choose the appropriate answer.

1. Which one of the following is an example for a metal?
   a. Iron b. Oxygen c. Helium d. Water
2. Oxygen, hydrogen, and sulphur are examples for
   a. metals b. non-metals
   c. metalloids d. inert gases
3. Which of the following is a short and scientific way of representing one molecule of an element or compound?
   a. Mathematical formula
   b. Chemical formula
   c. Mathematical symbol
   d. Chemical symbol
4. The metal which is liquid at room temperature is
   a. chlorine b. sulphur
   c. mercury d. silver
5. An element which is always lustrous, malleable and ductile is
   a. non-metal b. metal c. metalloid d. gas

II. Fill in the blanks.

1. The smallest particle of matter that can exist by itself is _____.
2. A compound containing one atom of carbon and two atoms of oxygen is _____.
3. _____ is the only non-metal which conducts electricity.
4. Elements are made up of _____ kinds of atoms.
5. _____ of some elements are derived from Latin or Greek names of the elements.
6. There are _____ number of known elements.
7. Elements are the _____ form of pure substances.
8. The first letter of an element is always written in _____ letter.
9. Molecule containing more than three atoms are known as_____.
10. _____ is the most abundant gas in the atmosphere.

III. Analogy.

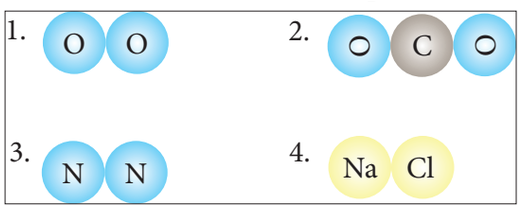
1. Mercury : Liquid at room temperature :: Oxygen: _____.
2. Non-metal conducting electricity : _____ :: Metal conducting electricity : Copper
3. Elements : Combine to form compounds :: Compounds :_____.
4. Atoms : Fundamental particle of an element :: _____ : Fundamental particles of a compound.

IV. State true of false. If false, give the correct statement.

1. Two different elements may have similar atoms.
2. Compounds and elements are pure substances.
3. Atoms cannot exist alone. They can only exist as groups called molecules.
4. NaCl represents one molecule of sodium chloride.
5. Argon is mono atomic gas.

V. Answer in brief.

1. Write the chemical formula and name the elements present in the following compounds.
   a. Sodium chloride
   b. Potassium hydroxide
   c. Carbon dioxide
   d. Calcium oxide
   e. Sulphur dioxide
2. Classify the following molecules as the molecules of element or compound.



3. What do you understand by chemical formula of a compound? What is its significance?
4. Define the following terms with an example for each.
   a. Element
   b. Compound
   c. Metal
   d. Non-metal
   e. Metalloid
5. Write the symbols for the following elements and classify them as solid, liquid and gas.
   Aluminum, Carbon, Chlorine, Mercury, Hydrogen and Helium
6. Classify the following as metals, non-metals and metalloids.
   Sodium, Bismuth, Silver, Nitrogen, Silicon, Carbon, Chlorine, Iron, Copper
7. Classify the following as elements and compounds.
   Water, Common salt, Sugar, Carbon dioxide, Iodine and Lithium
8. Write the chemical formula for the following elements.
   a. Hydrogen b. Nitrogen
   c. Ozone d. Sulphur
9. What are elements? What are they made of? Give two examples.
10. Define molecule.
11. What are compounds? Give two examples.
12. Give an example for the elements derived from their Latin names.
13. What is atomicity of elements?
14. Calculate the atomicity of H_2SO_4.

VI. Answer in detail.

1. Differentiate metals and non-metals.
2. Explain the characteristics of compounds
3. Describe the different ways in which we can write the symbols of elements. Give appropriate examples.

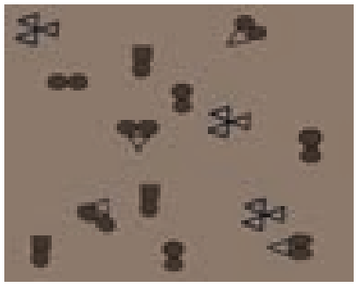
4. Differentiate between elements and compounds.
5. Write any five characteristics of compounds.
6. Compare the properties of metals and non-metals. Give three examples for each.
7. Write down the properties of metalloids.

VII. Rewrite the given sentence in correct form.

1. Elements contain two or more kind of atoms and compounds contain only one kind of atom.

VIII. Higher Order Thinking Skills.

1. List out the metals, non-metals and metalloids which you use in your house, schools. Compare their properties.
2. What changes take place in the movement and arrangement of particles during heating process?
3. In the diagram given below, the circle, square and triangle represent the atoms of different elements.



Identify all combinations that represent
   a. molecule of a compound
   b. molecule of an element consisting of two atoms
   c. molecule of an element consisting of three atoms

4. Aakash noticed that the metal latch on gate was difficult to open during hot sunny days. However, it was not difficult to open the same latch at night. Aakash observed that the latch and the gate are exposed to the sun during day time.
   a. Formulate a hypothesis based on the information provided.
   b. Briefly state how you would test the hypothesis.

IX Consider the following statements and choose the correct option.

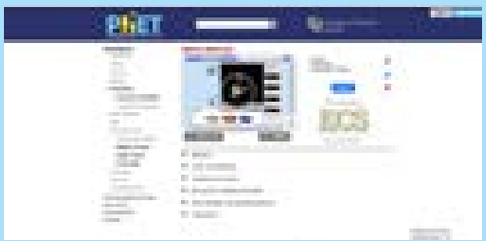
1. **Assertion:** Oxygen is a compound.
   Reason: Oxygen cannot be broken down into anything simpler.
2. **Assertion:** Hydrogen is an element.
   Reason: Hydrogen cannot be broken down into anything simpler.
3. **Assertion:** Air is a compound.
   Reason: Air consists of carbon dioxide.
4. **Assertion:** Air is a mixture of elements only.
   Reason: Only nitrogen, oxygen and neon gases exist in air.
5. **Assertion:** Mercury is solid in room temperature.
   Reason: Mercury is a non-metal.

   a. Both assertion and reason are true and reason is the correct explanation of assertion.
   b. Both assertion and reason are true, but reason is not the correct explanation of assertion.
   c. Assertion is true but reason is false.
   d. Assertion is false but reason is true.

ICT CORNER

Matter around us

Let's build the molecules.



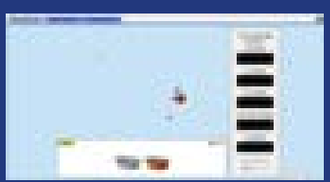
PROCEDURE :

Step 1: Use the URL to reach stimulation page. Click 'Download' and launch the stimulation.

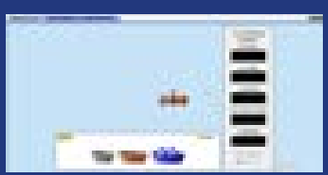
Step 2: Drag the atoms from the kit which is at the bottom of the display to 'make molecule'. Click on "3D" to see the molecule in 3 dimension. And drag that molecule to 'Your molecule collection' on the left side window.

Step 3: Click on the 'collect multiple' tab on the top of the window for more molecules.

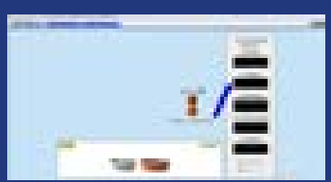
Step 4: Click on the 'Larger molecules' tab to make larger molecules.



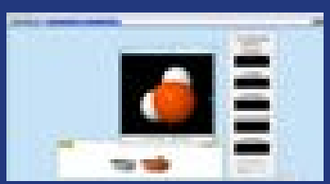
Step 1



Step 2



Step 3



Step 4

Matter around us URL:

https://phet.colorado.edu/en/simulation/build-a-molecule

*Pictures are indicative only

*If browser requires, allow Flash Player or Java Script to load the page.