6. Composition of matter

Can you recall?

1. What are the various states of matter?
2. What is the difference in ice, water and steam?
3. What are the smallest particles of matter called?
4. What are the types of matter ?

We saw in the previous standards that all the objects that we see around us and also those which cannot be seen are made of same or the other matter.

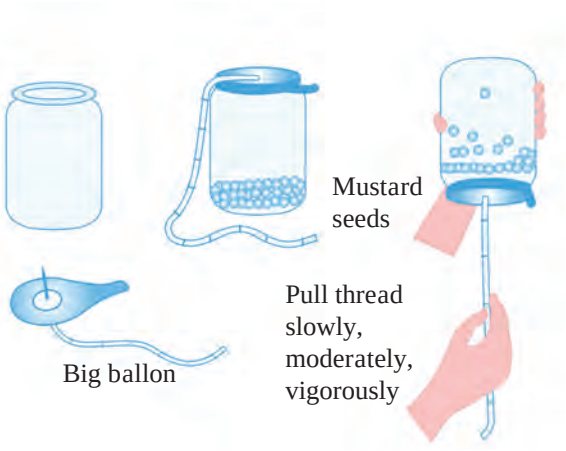
Can you tell?

1. Classify the following matter into three groups. Cold drink, air, sherbat, soil, water, wood, cement.
2. What are the states of matter that you used as criteria for the above classification ?

Try this

Take some mustard seeds in a transparent plastic jar. Thread a long thread at the centre of a big ballon by means of a needle and tie it tight. Stretch this rubber diaphragm and fix it on the mouth of the jar by means of a rubber band. Pull the diagphragm up and down with the help of the thread first slowly, then with moderate force and then vigorously. Record your observation in the following table.

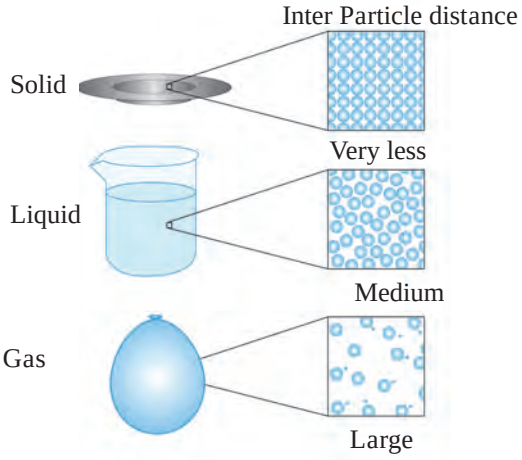
Mode of pulling the diaphragm up and down	Movement of the mustard seeds
Slow	Vibration in the same place
with moderate force	.....
vigorous	.....



6.1 Movement of mustard seeds

On the above experiment we give energy, less or more, to the mustard seeds by pulling the diaphragm up and down, making them move differently. The particles in the solid, liquid and gaseous states of matter have movement some what similar to that.

An intermolecular force of attraction acts between the particles (atom or molecules) of matter. The extent of the particle movement is determined by the strength of this force. The particles of solid are very close to each other and vibrate at their fixed positions. Due to this, solids get properties like definite shape and volume and also high density and non-compressibility. The strength of intermolecular force is moderate in the liquid state. Though it is not strong enough to fix the particles in definite position, it is strong enough to hold them together. As a result, liquids have definite volume. However they have fludity and their shape is not definite but changes in accordance with the container. The intermolecular



6.2 Physical state of matter : submicroscopic picture

force is very weak in gases. Therefore the constituent particles of gases move freely and occupy all the available space. Consequently gases have neither definite shape nor definite volume. Figure 6.2 shows schematic representation of submicroscopic picture of the physical states of matter and the table 6.3 shows the characteristics of the states of matter.

Physical state of matter	Fluidity/ Rigidity/ Plasticity/ Elasticity	Volume	Shapes	Compressibility	Intermolecular force	Distance between particles
Solid	Rigid/plastic/ elastic	Definite	Definite	Negligible	Strong	Minimum
Liquid	Fluid	Definite	Indefinite	Very small	Moderate	Moderate
Gaseous	Fluid	Indefinite	Indefinite	Very high	Very weak	Very large

6.3 : Characteristics of States of matter

Can you tell?

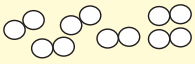
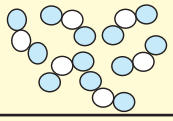
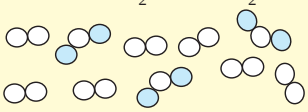
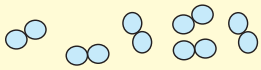
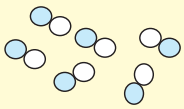
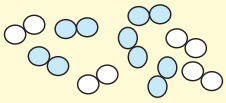
Write the composition of the following materials by means of chemical formulae and classify them accordingly.

Name of the material	Chemical formula/composition	Type of matter
Water		
Carbon		
Oxygen		
Air		
Aluminium		
Brass		
Carbon dioxide		

This is the second method of classification of matter. In this method the criterion used for classification of matter is chemical composition of matter. We have seen in the previous standard that matter is classified into three types **'element', 'compound' and 'mixture'** by considering whether the smallest particles of matter are similar or different and what are they made of. All the smallest particles (atoms/ molecules) in an element or a compound are alike, however, the smallest particles in a mixture are of two or more types.

The smallest particles of an element contain identical atoms. For example, each molecule of oxygen contains two oxygen atoms in bonded state. The smallest particles (molecules) of a compound are formed by joining two or more types of atoms to each other. For example, each molecule of water contain two hydrogen atoms joined to one atom of oxygen. The smallest particles of a mixture are atoms/molecules of two or more elements/compounds. For example, the main constituent molecules of the mixture namely, air are N_2, O_2, Ar, H_2O, CO_2. Similarly, the mixture (an alloy) brass contain atoms of copper (Cu) and zinc (Zn), while bronze contain atoms of the elements copper (Cu) and tin (Sn).

The figure 6.4 shows a schematic submicroscopic picture of the types of matter, namely, element, compound and mixture and also their characteristics.

Element	Compound	Mixture
Nitrogen molecules (N_2) 	Nitrogen dioxide molecules (NO_2) 	Mixture of N_2 and NO_2 
Oxygen molecules (O_2) 	Nitric oxide molecules (NO) 	Mixture of N_2 and O_2 
Constituent substance of element is only one, and it is that element itself	Constituent substance of a compound is only one and it is that compound itself	Constituent substances of a mixture are two or more elements and/or compounds
All the atoms/molecules of an element are alike	All the molecules of a compound are alike	Atoms\molecules of a mixture are of two or more types
All the atoms in a molecule of an element are alike and are joined to each other by chemical bonds.	The constituent atoms of a molecule of a compound are of two or more types and are joined to each other by chemical bonds.	The constituent molecules of mixture are different from each other and are not joined by chemical bonds.
Atoms/molecules of different elements are different	The proportion of constituent elements in a compound is constant.	The proportion of constituent substances in a mixture can change.
-	Properties of a compound are different than those of the constituent elements	The proporties of constituent substances are retained in the mixture.

6.4 : Element, Compound, Mixture - a schematic submicroscopic picture and characteristics

Do you know?

Water : A compound Pure water is a compound formed by chemical combination of the elements hydrogen and oxygen. Whatever may be the source of water, the proportion of its constituent elements oxygen and hydrogen by weight is always 8:1. Hydrogen is an inflammable gas while oxygen gas supports combustion. However, the compound water formed by chemical combination of the gaseous elements hydrogen and oxygen is a liquid. It is neither inflammable nor does it support combustion. On the contrary it helps to extinguish fire.

Milk : A mixture Milk is a mixture of water, lactose, fats, protein and a few more natural substances. The proportion of various ingredients of milk is different as per its source. The proportion of fats in cow milk is 3-5 %, while it is 6-9 % in buffalo milk. The ingredient water is naturally present in large proportion in milk. Therefore milk exists in liquid state. The sweetness of milk is due to the ingredient called lactose. In other words, the proporties of the constituent substances are retained in milk.

Types of element

Try this

Take the following objects : iron nail/sheet, copper wire, aluminium wire, a piece of coal. Rub each object on a fresh surface of sandpaper and observe. Hammer each object with force. (Take care not to hurt yourself.) Record your observations in the following table.

Object	Is the surface shining? yes/ no	Does the shape flatten/break into small pieces on hammering ?
Iron nail		
Copper wire		
Aluminium wire		
Coal piece		

The objects in the above activity are made of the elements iron (Fe), copper (Cu), aluminium (Al) and carbon (C) respectively. Fill the following table on the basis of the observations obtained on doing the above two tests on each of the objects.

Elements having a shiny surface	
Elements that flatten on hammering	
Elements with a dull surface	
Elements that break on hammering	

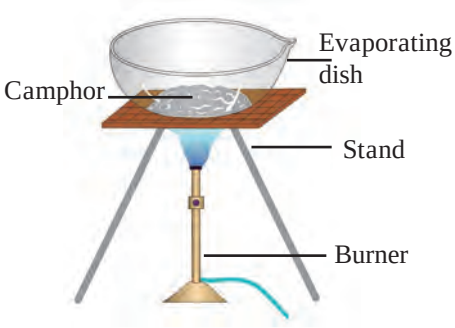
You noticed that element has different physical properties like lustre/paleness, malleability/ brittleness. According to that elements are classified. In early times, elements were classified into 'Metals' and 'Non metals'. After invention of new elements a new type 'Metalloid' is discovered. The detail study of these type elements will be made in chapter Metals and Non metals.

Types of compound

Try this

Apparatus : Evaporating dish, tripod stand, burner, etc.
Chemicals : Camphor, washing soda, blue vitriol, sugar, glucose, urea.

Keep the evaporating dish on the tripod stand (fig 6.4). Take some camphor in the evaporating dish. Heat the camphor in the dish strongly with the help of a burner. Find out what remains behind in the evaporating dish. Repeat the above procedure using limestone, washing soda, blue vitriol, sugar, glucose and urea instead of camphor. Record your observation in the following table. (Do this activity carefully under the supervision of your teacher, as some of the powders may catch fire.)



6.4 Experimental figure

Powder in the evaporating dish	Whether there was a residue / no residue in the evaporating dish	Colour of the residue
Camphor		
Limestone		
.....		

You saw in the above activity that on heating strongly some compounds give residue while others do not give any residue or give a blackish residue. The black residue is mainly made of carbon. Moreover, when such compounds are strongly heated in air, combine with oxygen to form some gaseous substances. In case their combustion is not complete, black coloured carbon remain behind as residue. These compounds are called **organic compounds or carbon compounds**. For example materials like, carbohydrates, proteins, hydrocarbons (for example, petrol, cooking gas) are made of organic compounds. The comphor, sugar, glucose and urea used in the above activity are organic compounds. On the other hand the compounds that decompose on strong heating to leave a residue behind are **inorganic compounds**. Comman salt, soda,

rust, blue vitriol, limestone are inorganic compounds. In addition there is one more type of compounds, namely **complex compounds**. The molecules of compounds have a complex structure formed by many atoms and in the centre of this structure metal atoms are also included. Chlorophyll that contains magnesium, hemoglobin that contain iron, cyanocobalamine (vitamin B-12) that contain cobalt are some examples of complex compounds.

Various atoms in the molecules of compounds are joined by **chemical bonds**. We are going to look at that later.

Types of mixtures

Try this

Take three beakers. Take a little sand and water in the first beaker. Take some crystals of blue vitriol and water in the second beaker. Take some blue vitriol and sand in the third beaker. Stir the materials in all the three beakers and observe. Record your observation in the following table.

Beaker Number	Materials taken	What change seen on stirring	Number of phases in the mixture	Types of mixture
1				
2				
3				

The part of matter having uniform composition is called **phase**. Write the third column of the table the number of phases seen in each of the beakers ofter stirring. When all the components of a mixture form one phase, it is called **homogeneous mixture**. When the components of a mixture are distributed into two or more phases it is called a **heterogeneous mixture**.

Can you tell?

In the above activity after stirring a homogeneous mixture is formed in only one beaker. Which is that ?

Always remember

All the particles of a solid that stay together (or are in the same container) constitute a single phase. (eg., a heap of stones.) A liquid substance along with all the soluble substances dissolved in it together constitute a single phase. (eg., sea water) A liquid or all its drops present together or in the same container constitute a single phase. (eg., rain drops) The liquids present together or in the same container, but not mixed with each other, constitute separate phase. (eg., oil and water) All the gases present together constitute a single phase. (eg., air)

Try this

Take three beakers. Take 10 g common salt in the first beaker, 10 g saw dust in the second beaker and 10 ml milk in the third beaker. Add 100 ml water to all the three beakers and stir. which of the mixtures shows separate water phase? Place the three beakers in front of a vertically held paper and pass a laser beam through the beakers from the opposite side. (use the laser beam under the guidance of teacher.) At the same time observe what appears on the paper in front of the beaker. Also look at the beaker from the side. Arrange three filtration assemblies using conical flask, funnel and filter paper for doing filtration. Stir the mixtures in the three beakers and carry out filtration. Record all the observations in the following table.

Beaker	Components of the mixture	Separate aqueous phase seen/not seen	Transperent/ opaque	Components are separated/ not separated by filtration

Solution : A homogeneous mixture of two or more substances is called **solution**. In the first beaker in the above activity a homogeneous mixture of water and salt is formed. It is called a salt solution. That component of a solution which is present in the largest proportion is called **solvent.** The other components which are in less proportion than the solvent are called **solutes**. The process of forming a solution by mixing solutes in a solvent is called dissolution. According to the states of the components solution can be of many types. The solution such as sea water, blue vitriol dissolved in water, salt dissolved in water, sugar syrup are of the type solid in liquid. In addition to this, the solution can also be of the types **liquid in liquid** (for example, vinegar, dilute sulphuric acid), **gas in gas** (for example, air) **solid in solid'** (for example, alloys like brass, steel, stainless steel, etc), **gas in liquid** (for example, chlorinated water, hydrochloric acid). The composition of a homogeneous mixture, that is to say solution, is uniform throughout the bulk. If solvent is a transparent liquid, the solution is also transparent and it passes through a filter paper.

Suspension : In the second beaker in the above activity a heterogeneous mixture of water and saw dust was formed. It is a mixture of a liquid and a solid. Heterogeneous mixture of a liquid and a solid is called a **suspension**. The diameter of the solid particles in a suspension is larger than 10^{-4} m. Therefore light cannot transmit through it. More over these solid particles remain on an ordinary filter paper as residue and therefore the liquid and solid components of a suspension get separated by filtration.

Colloid : The mixture of water and milk in the third beaker in the above activity is transluscent. It means that, when light is incident on the surface of this mixture, it is partly transmitted and partly scattered. This is because the tiny particles of milk phase in this heterogeneous mixture are dispered evenly in water phase, and the diameter of these particles is around 10^{-5}m. Such a heterogeneous mixture is called a **colloid**. However as the pores of an ordinary filter paper are larger than colloid, the heterogeneous mixture, cannot be separated by filtration. Milk is itself a colloid. In it, the solid and liquid particles of proteins, fats, etc. having a diameter around 10^{-5}m are dispersed in the aqueous medium. Apart from this, there are some more types of colloids such as 'solid in gas' (for example, smoke), 'liquid in gas' (for example, fog, cloud), etc.

Let us understand compounds : while studying matter we have seen that element is a type of matter having the simplest composition. On inspection of the composition of the types compound and mixture it is learnt that they are formed from two or more units. Whether these units are in a joined state with each other or separate decides whether the matter is a compound or a mixture.

Try this

Take two evaporating dishes. Take 7 g iron filings in the first dish and 4 g sulphur in the second. Take a horse shoe magnet near the matter in both the dishes and observe. Transfer the entire iron filings from the first dish to the second, stir with a glass rod and observe by taking the horseshoe magnet near the matter. Also observe the colour of the matter. Now heat the matter in the second dish for a while and let it cool. Observe the colour change, if any in the matter and observe whether there is any effect of the horseshoe magnet on it. Record all the observation in the following table.

Action	Colour of matter	Effect of horseshoe magnet
Iron filings and sulphur were mixed in the dish		
Iron filings and sulphur in the dish were heated together		

In the above activity, on testing the matter obtained by mixing iron filings and sulphur with horse shoe magnet (step 3) it was found that the resulting matter was a mixture of iron and sulphur and possessed properties of both the components. Some particles were yellow. They were of sulphur. Some particles were black. They were iron particles. The property of iron particles to get attracted towards magnet was unchanged. In other words the components iron and sulphur were in free state in that matter. On the contary when iron filings and sulphur were heated together and cooled there was no effect of magnet and the characteristic yellow colour of sulphur also disappeared.

From this we understand that the matter formed in the above activity is different from the original components. A chemical combination took place between iron and sulphur due to heating in the above activity. The atom of iron and sulphur became joined by chemical bond to form molecules of a new compound.

Molecular formula and valency : There is a definite proportion of the constituent elements in a compound. Certain number of the atom of the constituent elements are joined to each other in a molecule of a compound. Molecular formula indicates the number of atom of each of the constituent elements present in one molecule of a compound. A molecular formula includes the information regarding the symbols of the all the constituent elements and their respective number as subscripts.

Can you tell?

Molecular formulae of some compounds are given in the following table. Use these to fill in the gaps in the table.

Sr. No.	Name of the compound	molecular formula	Constituent elements	Number of atoms of constituent elements
1.	Water	H_2O	H O	2 1
2.	Hydrogen chloride	HCl	... ...	... ...
3.	Methane	CH_4	... ...	... ...
4.	Magnesium chloride	$MgCl_2$	... ...	... ...

We have seen the relationship between a molecular formula and the number of atom of various elements in molecule. The ability of joining to another atom with a chemical bond is a chemical property of each atom. This ability is indicated by a number and this number is called valency of that atom. An atom forms as many chemical bonds with other atom as its valency. Generally valency of an element remain constant in its various compounds.

Do you know?

Scientists performed many experiments regarding composition of compounds during 18th and 19th contury and from that they deduced the valencies of elements.

Complete the table

Molecular formulae of various compounds formed by hydrogen with other elements are given in the following table. From that, deduce the valencies of the concerned elements.

Sr. No.	Molecular formula of a compound	Constituent Elements		Valency of 'H'	Number of bonds formed by 'X' with 'H'	Valency 'X'
		H	X			
1	HCl	H	Cl	1	1	1
2	H_2O	H	O	1	2	2
3	H_2S			1		
4	NH_3			1		
5	HBr			1		
6	HI			1		
7	NaH			1		
8	CH_4			1		

Valencies of the constituent elements can be deduced from the known molecular formula of a compound. The basis for this is the univalency of hydrogen. On the other hand the molecular formula of a compound can be written from the known valencies of the constituent elements by the method of cross multiplication.

Cross multiplication method for writing the molecular formula of simple compounds

Step 1 : To write symbols of constituent elements.

C O

Step 2 : To write the valency below the respective element.

C O
4 2

Step 3 : To cross multiply to obtain the number of atom of the constituent elements in the molecule of the compound

Step 4 : To write the formula of the compound obtained by cross multiplication.

C_2O_4

Step 5 : To write the final molecular formula of the compound. The number of constituent atoms in the final molecular formula should be the smallest possible whole numbers. For getting this, divide the formula obtaind in step 4 by a suitable number.

Formula obtained by cross multiplication : C_2O_4

Final molecular formula obtained by dividing by '2' : CO_2

Pairs of elements and their valencies are given in the following table. Use them logically to deduce the molecular formulae of the compounds formed from the pairs and write them in the last column.

Element	Valency	Molecular formula of the corresponding compound
C H	4 1	
N H	3 1	
Fe S	2 2	
C O	4 2	

Use your brain power

1. Deduce the molecular formulae of the compounds formed from the following pairs of elements.
   (i) H (valency 1) and O (valency 2)
   (ii) N (valency 3) and H (valency 1)
   (iii) Fe (valency 2) and S (valency 2)
2. The valencies of the atom H, O and N are 1, 2 and 3 respectively. The molecular formulae of these gaseous elements are H_2, O_2, and N_2 respectively. How many chemical bonds are there in each of these molecules?

Exercises

1. Choose the appropriate option and rewrite the following statements.

a. The intermolecular force is ..... in the particles of solid.
i. minimum ii. moderate iii. maximum iv. indefinite

b. Solids retain their volume even when external pressure is applied. This property is called ..... .
i. plasticity ii. incompressibility
iii. fluidity iv. elasticity

C. Matter is classified into the types mixture, compound and element, by applying the criterion ..... .
i. states of matter ii. phases of matters
iii. chemical composition of matter
iv. all of these

d. Matter that contain two or more constituent substances is called ..... .
i. mixture ii. compound
iii. element iv. metalloid

e. Milk is an example of type of matter called ..... .
i. solution ii. homogeneous mixture
iii. heterogeneous mixture iv. suspension

f. Water, mercury and bromine are similar to each other, because three are ..... .
i. liquids ii. compounds iii. nonmetals iv. elements

g. Valency of carbon is 4 and that of oxygen is 2. From this, we understand that there are ..... chemical bond/bonds between the carbon atom and one oxygen atom in the compound-carbon dioxide.
i. 1 ii. 2 iii. 3 iv. 4

2. Identify the odd term out and explain.

a. Gold, silver, copper, brass
b. Hydrogen, hydrogen peroxide, carbon dioxide, water vapour.
c. Milk, lemon juice, carbon, steel.
d. Water, mercury, bromine, petrol.
e. Sugar, salt, baking soda, blue vitriol.
f. Hydrogen, sodium, potassium, carbon.

3. Answer the following question.

a. Plants synthesize glucose in sunlight with the help of chlorophyll from carbon dioxide and water and give away oxygen. Identify the four compounds in this process and name their types.

b. In one sample of brass, the following ingredients were found : copper (70%) and zinc (30%). Identify the solvent, solute and solution from these.

c. Sea water tastes salty due to the dissolved salt. The salinity (the proportion of salts in water) of some water bodies Lonar lake - 7.9 %, Pacific Ocean 3.5 % , Mediterranean sea - 3.8 %, Dead sea - 33.7 %. Explain two characteristics of mixtures from the above information.

4. Give two examples each

a. Liquid element
b. Gaseous element
c. Solid element
d. Homogeneous mixture
e. Colloid
f. Organic compound
g. Complex compound
h. Inorganic compound
i. Metalloid
j. Element with valency 1
k. Element with valency 2

5. Write the names and symbols of the constituent elements and identify their valencies from the molecular formulae given below.

KCl, HBr, $MgBr_2$, K_2O, NaH, $CaCl_2$, CCl_4, HI, H_2S, Na_2S, FeS, $BaCl_2$

6. Chemical composition of some matter is given in the following table. Identify the main type of matter from their.

Name of matter	Chemical composition	Main type of matter
Sea water	$H_2O + NaCl + MgCl_2$+...	
Distilled water	H_2O	
Hydrogen gas filled in a ballon	H_2	
The gas in LPG cylinder	$C_4H_{10} + C_3H_8$	
Baking soda	$NaHCO_3$	
Pure gold	Au	
The gas in oxygen cylinder	O_2	
Bronze	Cu + Sn	
Diamond	C	
Heated white powder of blue vitriol	$CuSO_4$	
Lime stone	$CaCO_3$	
Dilute hydrochloric acid	$HCl + H_2O$	

7. Write scientific reason.

a. Hydrogen is combustible, oxygen helps combustion, but water helps to extinguish fire.

b. Constituent substances of a colloid cannot be separated by ordinary filtration.

c. Lemon sherbat has sweet, sour and salty taste and it can be poured in a glass.

d. A solid matter has the properties of definite shape and volume.

8. Deduce the molecular formulae of the compound obtained from the following pairs of elements by the cross multiplication method.

a. C (Valency 4) & Cl (Valency1)

b. N (Valency 3) & H (Valency 1)

c. C (Valency 4) & O (Valency 2)

d. Ca (Valency 2) & O (Valency 2)

Project :

Collect the wrappers of readymade food stuff. Use the information given and prepare a chart of foodstuff and the ingredients in it. Procure the ingredients available. Discuss with friends and teacher, test the procured ingredients with combustion test under the supervision of your teacher. Thereby identify the ingredients as organic or inorganic.

JUSXYB