13. Chemical Change and Chemical Bond

Can you recall?

1. What are the methods of classification of changes ?
2. What is the difference between physical and chemical change ?
3. Classify the follwing changes into physical and chemical change.

Ripening of mango, melting of ice, boiling of water, dissolution of salt in water, Ripening of banana, fragrance on ripening fruit, darkening of a cut potato, bursting of an inflated balloon, sound of bursting fire cracker, foul smell from a spoiled food.

During any chemical change, composition of original substance changes to form new substance with a different composition and properties. How to identify a chemical change?

Try this

Take the lemon juice in a clean glass. Take two drops of the lemon juice in a spoon and taste. Add a pinch of baking soda in the glass of lemon juice. Did you notice bubbling around the particles of soda? Did you hear a sound on taking your ear near the glass? Now again taste it. Did it taste as sour as it was in the beginning?**(Above activity is to be done using clean apparatus and edible material. Then only it is possible to test the 'taste', otherwise keep in mind that the testing of 'taste' cannot be done.)**

Many perceivable observations are noticed during the above activity. A gas is seen to be liberating in the form of bubbles. A low sound is heard. The white solid particles of the baking soda disappear. The original sour taste becomes mild or diminishes. From this, it is understood that a new substance having a different taste is formed. At the end of the above change, the taste of the substance was different means its composition was different. Thus, during the above change, the composition of the original substance changed to form a new substance with different properties. Thus, the change that takes place on adding baking soda to lemon juice is a chemical change. Sometimes some characteristic observations are perceived during a chemical change. These enable us to know that a chemical change has taken place. Some of these observations are enlisted in the table 13.1

Change in colour, taste, release of gases, etc

13.1 Some observations of chemical change

Chemical change and word equation : During a chemical change the chemical composition of the original matter changes and new substances having different properties and different chemical compositon are formed. A chemical equation can be written for a chemical change, if the exact change in chemical composition is known. Names and chemical formulae of the original substance and newly formed substance are used while writing a chemical equation. For example, when baking soda is added to lemon juice a chemical change takes place in the citric acid present in the lemon juice and the gas formed is carbon dioxide. The word equation can be written for this chemical reaction as follows

Formation of CO_2 with effervescence

13.2 Experiment figure

Citric acid + Sodium bicarbonate ⟶ Carbon dioxide + Sodium citrate

Acid + Alkali ⟶ CO_2 + Salt

This is neutralization reaction.

Always remember

First step of writing a chemical equation is to write a word equation by using the names of the concerned substances. When the chemical formula is written in place of each of the names, it becomes a chemical equation. While writing a chemical equation, original substances are written on the left side and newly formed substances are written on right side and an arrow is drawn in between. Arrow head points towards the substances formed. Arrow indicates the direction of the reaction. Substances written on the left side of the arrow are original substances that take part in the reaction. They are called reactants. New substances formed as a result of the reaction are called products. Place for the products of a reaction is on the right side of the arrow.

Chemical changes in everyday life : We find many examples of chemical changes in our surrounding, body, home and laboratory. Let us see some chemical changes for which word and chemical equation can be written easily.

Natural chemical changes

a. Respiration : Respiration is a continuously occuring biological process. In this process, we inhale the air and exhale carbon dioxide and water vapour. After an in depth study it is learnt that glucose in the cells reacts with oxygen in the inhaled air to form carbon dioxide and water. The word equation and the chemical equation of this chemical reaction are as follows. (Here, the chemical equation is not balanced.)

Word equation :

Glucose + Oxygen $\xrightarrow{\text{respiration}}$ Carbon dioxide + Water

Chemical equation :

$C_6H_{12}O_6 + O_2 \xrightarrow{\text{respiration}} CO_2 + H_2O$

Try this

Take some freshly prepared lime water (solution of calcium hydroxide) in a test tube. Keep on blowing in it with a blow tube. What is seen after some time? Did the colourless lime water turn milky? After some more time you will find that a white insoluble solid settles at the bottom of the test tube. This is a precipitate of calcium carbonate. The turning milky millgot lime water means that the blown gas mixed in it was carbon dioxide.

Carbon dioxide + Calcium hydroxide ⟶ Calcium carbonate + Water

Write a chemical equation for the above word equation.

b. Photosynthesis : You know that green plants perform photosynthesis in sunlight. A word equation and a chemical equation (unbalanced) can be written for this natural chemical change as follows.

Word equation : Carbon dioxide + Water $\xrightarrow[\text{green plant}]{\text{Sunlight}}$ Glucose + Oxygen

Chemical equation : $CO_2 + H_2O \xrightarrow[\text{green plant}]{\text{Sunlight}} C_6H_{12}O_6 + O_2$

Man made chemical changes : We bring about many chemical changes for our use in everyday life. Let us see some of them. The chemical change that we saw in the first activity is used in the cold drink called 'soda-lemon'. It means that it is an useful man made chemical change.

a. Combustion of fuels : Wood, coal, petrol or cooking gas are burnt for getting energy. The common substance that burns in all these fuels is 'Carbon'. During the combustion process carbon combine with oxygen in air and the product carbon dioxide is formed. A common equation can be written for all these combustion processes as follows.

Word equation : Carbon + Oxygen $\longrightarrow$ Carbon dioxide

Chemical equation : $C + O_2 \longrightarrow CO_2$

Combustion of fuel is a fast and irreversible chemical change.

b. Cleaning Shahabad tile with dilute hydrochloric acid : The chemical composition of Shahabad tile is mainly calcium carbonate. During its cleaning with hydrochloric acid the upper layer of the tile reacts with hydrochloric acid and three products are formed. One of them is calcium chloride, which being soluble in water, gets washed away with water. The second product is carbon dioxide; its bubbles mix up in air. The third product, water mixes with water. The following equation can be written for this chemical change.

Word equation :

Calcium cabonate + Hydrochloric acid $\longrightarrow$ Calcium chloride + Carbon dioxide + water

Write a chemical equation (unbalanced) for the above reaction.

c. Softening of hard water : Some wells or tube wells have hard water. It is brackish to taste and does not form lather with soap. This is because of hard water contains the chloride and sulphate salts of calcium and magnesium in dissolved state. To soften the hard water, a solution of washing soda is added to it. This results in a chemical reaction to form a precipitate of insoluble carbonate salts of calcium and magnesium. As the dissolved salts of calcium and magnesium go out in the form of precipitate of the carbonate salts, the water is softened. The following equation can be written for this chemical change.

Word equation :

Calcium chloride + Sodium carbonate $\longrightarrow$ Calcuim carbonate+ Sodium chloride

Chemical equation (unbalanced) :

$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + NaCl$

Write word and chemical equations for the chemical change taking place in magnesium salts during the softening of hard water.

We saw that composition of matter changes during a chemical change and new substances having different properties are formed. When this happens, some chemical bonds in the reactants break and new substances called products are formed by formation of new chemical bonds. We have also seen in the chapter 'Composition of Matter' that the number of chemical bonds formed by one atom is its valency. Now let us see what is a chemical bond.

Chemical bond : We have seen the relationship between electronic configuration and valency of an element in the chapter 'Inside the Atom'. Noble gases do not form any chemical bond as their electron octet/duplet is complete while the atoms with incomplete electron octet/duplet form chemical bonds. Reason for this is that an atom uses its valence electrons during formation of a chemical bond. Moreover on forming chemical bonds equal to its valency the atom attains the electronic configuration of complete octet/duplet.

1. Ionic bond : Let us first see how the compound sodium chloride is formed from the atoms of the constituent elements sodium and chlorine. For this purpose let us see the electronic configuration of sodium and chlorine.

$_{11}Na$: 2,8,1; $_{17}Cl$: 2,8,7

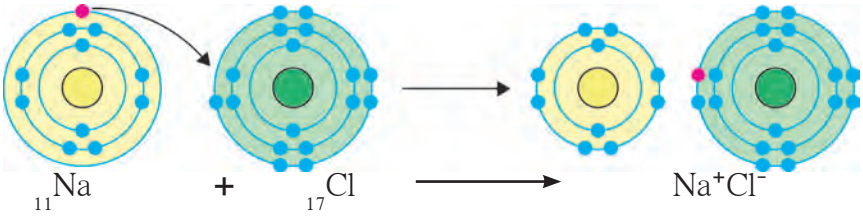
We have seen the correlation that the valency of sodium is one as it has one electron in its valence shell and the valency of chlorine is one as its valence shell is short of one electron to have a complete octet. On loss of a valence electron from 'M'shell, the penultimate shell 'L' of sodium atom becomes outermost shell. It has eight electrons in it. Effectively, sodium attains an electron octet state. However, the electron number, becomes 10. Hence the positive charge +11 on the sodium nucleus is imbalanced and a Na^+ cation, carrying net positive charge +1 is formed. On the other hand valence shell of chlorine atom contains an electron less to the octet state. On accepting an electron from outside, octet of chlorine is completed. However the charge balance is disturbed due to additon of an electron to the neutral chlorine atom. This results in the formation of an anion Cl^-, carrying a net negative charge -1.

When the elements sodium and chlorine combine, an atom of sodium gives its valence electron to a chlorine atom, whereby the cations Na^+ and anions Cl^- are formed. Due to the electrostatic force of attraction between opposite charges the oppositely charged ions get attracted to each other and a chemical bond is formed between them.

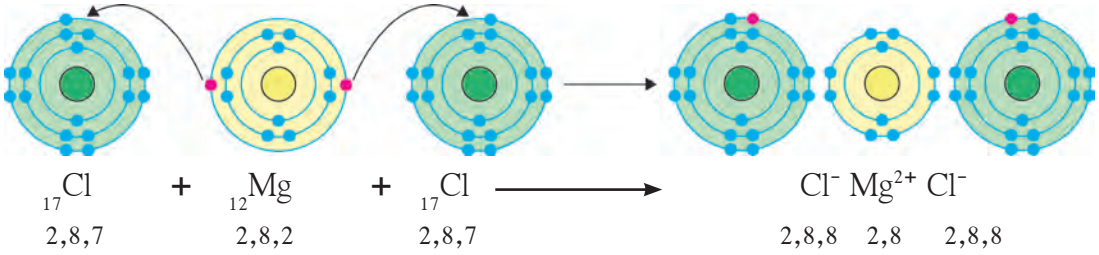
The chemical bond formed due to an elctrostatic force of attraction between the oppositely charged cation and anion is called an **ionic bond or an electrovalent bond**. The compound formed by means of one or more ionic bonds is called **ionic compound**.

Formation of an ionic compound sodium chloride from the elements sodium and chlorine is shown with the help of diagramatic representation of electronic configuration in the fig 13.3.

One ionic bond is formed due to the electrical charge +1 or -1 on an ion. The valency of an ion is equal to the magnitude of postive or negative charge on it. An ion forms the same number of ionic bonds as its valency.



13.3 Formation of Ionic bond of NaCl



13.4 Formation of Ionic bond in $MgCl_2$ molecule

The figure 13.4 shows how the ionic compound magnesium chloride is formed from the elements magnesium and chlorine.

Show the formation of the following ionic compounds from the corressponding elements using two methods namely, numerical and diagramatic representation of electronic configuration. (a) K^+F^-, from $_{19}K$ and $_9F$ (b) $Ca^{2+}O^{2-}$ from $_{20}Ca$ and $_8O$

2. Covalent bond : Generally a covalent bond is formed when atoms of two elements having similar properties combine. Such atoms cannot exchange electrons. Instead, these atoms share electrons with each other. The shared electrons become a common property of both the atoms and thereby the electron octet/duplet of both the atoms becomes complete. Let us first consider an example of the hydrogen molecule (H_2).

We have seen in the chapter 'Inside an Atom' that a hydrogen atom contains one electron, its duplet is short of one electron and therefore the valency of hydrogen is one. The two atoms of hydrogen are identical and have similar tendency and therefore they share their electrons with each other. As a result, the electron duplet of both the hydrogen atoms is complete and a chemical bond is formed between them.

The chemical bond formed by sharing of valence electrons of two atoms with each other is called a covalent bond. One covalent bond is formed by sharing of two valence electron. The figure 13.5 shows formation of the H_2 molecule from two hydrogen atoms, using diagramatic representation of elctronic configuration. A covalent bond between two atoms is also represented by dash joining their symbols.

13.5 Formation of Covalent bond in H_2 molecule

Now let us see how an H_2O molecule of a covalent compound is formed from hydrogen and oxygen atoms. (See fig. 13.6) There are six electrons in the valence shell of oxygen atom. It means that the electron octet in oxygen is short of two electrons and the valency of oxygen is '2'. In the H_2O molecule the oxygen atom completes its octet by forming two covalent bonds, one each with the two hydrogen atoms. While this happens, the duplets of the two hydrogen atoms also are completed.

13.6 Formation of Covalent bond in H_2O molecule

Use your brain power

There is one covalent bond between the component atoms H and Cl of the molecule HCl. Use this information to represent the formation of HCl molecule from H and Cl atoms diagramatically.

Exercises

1. Complete the statement by filling the gaps using appropriate term from the terms given in the bracket.
(slow, coloured, arrow, fast, smell, milky, physical, product, chemical, reactant, covalent, ionic, octet, duplet, exchange, sharing, equality sign)

a. An ..... is drawn in between the reactants and products while writing the equation for a chemical reaction.
b. Rusting of iron is a ..... chemical change.
c. The spoiling of food is a chemical change which is recognized from the generation of certain ..... due to it.
d. A colourless solution of calcium hydroxide in a test tube turns ..... on blowing in it through a blow tube for some time.
e. The white particles of baking soda disappear when put in lemon juice. This means that it is a ..... change.
f. Oxygen is a ..... in respiration.
g. Sodium chloride is ..... compound while hydrogen chloride is ..... compound.
h. Electron ..... is complete in each hydrogen in a hydrogn molecule.
i. Chlorine (Cl_2) molecule is formed by ..... of electrons between two chlorine atoms.

2. Explain by writing a word equation.

a. Respiration is a chemical change.
b. Hard water gets softened on mixing with a solution of washing soda.
c. Lime stone powder disappears on adding to dilute hydrochloric acids.
d. Bubbles are seen on adding lemon juice to baking soda.

3. Match the pairs.

a. Photosynthesis	i. Tendency to lose electrons
b. Water	ii. Reactant in combustion process
c. Sodium chloride	iii. Chemical change
d. Dissolution of salt in water	iv. Covalent bond
e. Carbon	v. Ionic bond
f. Fluorine	vi. Physical change
g. Magnesium	vii. Tendency to form anion

4. Show with the help of diagram of electronic configuration how the following compound are formed from the constituent atoms.

a. Sodium chloride b. Potassium fluoride
c. Water d. Hydrogen chloride

Project :

Prepare a list of the chemical changes that occur in your house and surroundings and discuss these in the class.

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