3. Chemical Reactions and Equations

- Chemical reactions
- Rules of writing chemical reaction
- Balancing a chemical equation
- Types of chemical reactions

Can you recall?

1. What are the types of molecules of elements and compounds?
2. What is meant by valency of elements?
3. What is the requirement for writing molecular formulae of different compounds? How are the molecular formulae of the compounds written?

In earlier standards we have seen how compounds are formed by chemical combination of elements. We have also learnt that the driving force behind formation of a chemical bond is to attain an electronic configuration with a complete octet. The atoms attain a complete octet by giving, taking or sharing of electrons with each other.

Chemical Reaction

Some of the scientists of the 18^{th} and 19^{th} century carried out fundamental experiments on chemical reactions. They proved from their experiments that during chemical reactions composition of the matter changes and that change remains permanent. On the contrary during physical change only the state of matter changes and this change is often temporary in nature.

Identify physical and chemical changes from the phenomena given in the following table.

Phenomenon	Physical change	Chemical change
1. Transformation of ice into water.	✓	
2. Cooking of food.		✓
3. Ripening of fruit.		
4. Milk turned in to curd.		
5. Evaporation of water.		
6. Digestion of food in the stomach.		
7. Size reduction of naphtha balls exposed to air.		
8. Staining of Shahbad or Kadappa tile by lemon juice.		
9. Breaking of a glass object on falling from a height.		

3.1 Some common phenomenon

Note : Do the following activities in a group of friends. Take help of your teacher wherever necessary.

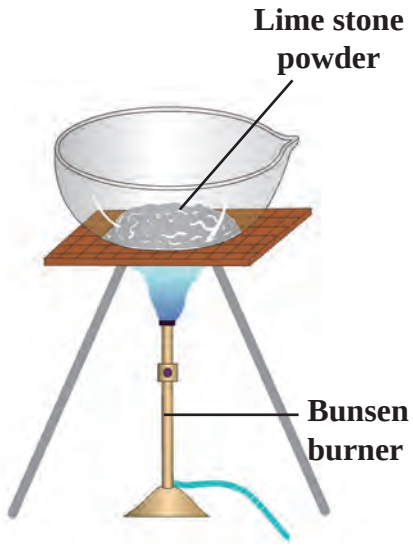
Try this.

Apparatus: Thermometer, evaporating dish, tripod stand, funnel, Bunsen burner, etc.

Chemicals : Lime stone powder, copper sulphate, calcium chloride, potassium chromate, zinc dust, sodium carbonate, phthalic anhydride, etc.

Procedure : Carry out the activities 1 to 5 as given below. Read and record the temperatures in the activities 2 to 4.

1. Take a spoonful of lime stone powder in an evaporating dish. Heat it strongly on a high blue flame.
2. Add zinc (Zn) dust into the copper sulphate ($CuSO_4$) solution.
3. Add potassium chromate (K_2CrO_4) solution to barium sulphate ($BaSO_4$) solution.
4. Add sodium carbonate (Na_2CO_3) solution to the calcium chloride ($CaCl_2$) solution.
5. Take phthalic anhydride in the evaporating dish. Close the end of the stem of a funnel with a cotton plug. Keep this funnel inverted on the evaporating dish. Heat the evaporating dish on a tripod stand slowly on a low flame. What did you observe in the funnel during heating?



3.2 To heat lime stone powder

Record the observation of all the activities. What did you find?

Complete the following observation table with reference to the activities 1 to 5.

Activity	Colour change (if present)	Gas released (yes/no)	Temperature change (if present)	Nature of change (chemical /physical)
1				
2				
3				
4				
5				

3.3 Observation table

Find out

Observe and keep a record of the physical and chemical changes that you experience in your daily life.

A physical change takes place due to change in the parameters such as temperature, pressure. Often a physical change in reversible. The composition of matter remains the same in a physical change. For example, ice is transformed into water on heating and water is transformed into ice on cooling. On the contrary, if the composition of matter changes during a process then it is called a chemical change. When we call a particular process or phenomenon as a chemical change, some chemical reactions are taking place in the concerned matter.

A chemical reaction is a process in which some substances undergo bond breaking and are transformed into new substances by formation of new bonds. The substances taking part in chemical reaction are called reactants, whereas the substances formed as a result of a chemical reaction by formation of new bonds are called products. For example, formation of carbon dioxide gas by combustion of coal in air is a chemical reaction. In this reaction coal (carbon) and oxygen (from air) are the reactants while carbon dioxide is the product. A chemical reaction is represented by writing a chemical equation.

Chemical equations

Let us first look at a chemical reaction. In the activity 2, a colourless solution of zinc sulphate ($ZnSO_4$) is formed on addition of zinc dust to the blue solution of copper sulphate ($CuSO_4$). This chemical reaction can be written in brief as follows.

Aqueous solution of copper sulphate + zinc dust $\longrightarrow$ Aqueous solution of zinc sulphate + copper ..... (1)

This simple way of representing a chemical reaction in words is called a 'Word Equation'.

A word equation can be written in a further condensed form by using chemical formulae as follows.

$$CuSO_4 + Zn \longrightarrow ZnSO_4 + Cu \text{.....(2)}$$

The representation of a chemical reaction in a condensed form using chemical formulae is called as the chemical equation. In the above equation copper sulphate ($CuSO_4$) and zinc (Zn) are the reactants. They react with each other to form copper particles (Cu) and a solution of the colourless zinc sulphate ($ZnSO_4$) as the products having totally different properties. The ionic bond in the reactant $CuSO_4$ breaks and the ionic bond in the product $ZnSO_4$ is formed during the reaction.

Writing a Chemical Equation

Let us now see the conventions followed while writing a chemical equation.

1. In a chemical equation the reactants are written on the left hand side while the products on the right hand side. An arrow heading towards the products is drawn in between them. This arrow indicates the direction of the reaction.

2. If the reactants or products are two or more, they are linked with a plus sign (+) in between them. For example, in the equation (2) a plus sign (+) is drawn in between the reactants $CuSO_4$ and Zn. Similarly, a plus sign (+) is drawn in between the products $ZnSO_4$ and Cu.

3. To make the chemical equation more informative the physical states of the reactants are indicated in the equation. Their gaseous, liquid and solid states are indicated by writing the letters (g), (l) and (s), respectively in the brackets. Moreover, if the product is gaseous, instead of (g) it can be indicated by an arrow $\uparrow$ pointing upwards. If the product formed is insoluble solid, in the form of a precipitate, then instead of (s) it can be indicated by an arrow $\downarrow$ pointing downwards. When reactants and products are in the form of solution in water, they are said to be present in aqueous solution state. This state is indicated by putting the letters aq in brackets after their formula. Thus, the equation (2) is rewritten as equation (3) shown below.

$$CuSO_4\,(aq) + Zn\,(s) \longrightarrow ZnSO_4\,(aq) + Cu\,(s) \text{ ..... (3)}$$

4. When heat is to be given from outside to bring about a reaction, it is indicated by the sign $\triangle$ written above the arrow that indicates the direction of the reaction. For example, the reaction in which slaked lime is formed on heating lime stone is written as follows.

$$CaCO_3\,(s) \xrightarrow{\Delta} CaO\,(s) + CO_2\uparrow \text{ ..... (4)}$$

Similarly, the fact that heat is released during the reaction between the aqueous solution of copper sulphate and zinc dust is indicated as follows.

$$CuSO_4\,(aq) + Zn\,(s) \longrightarrow ZnSO_4\,(aq) + Cu\,(s) + Heat \text{ ..... (5)}$$

5. It is necessary to fulfill certain conditions like specific temperature, pressure, catalyst, etc. to bring about some reactions. These conditions are indicated below or above the arrow indicating the direction of the reaction. For example, the reaction of a vegetable oil takes place at the temperature of 60 ^{0}C with hydrogen gas in presence of the Ni catalyst and is written as follows.

$$\text{Vegetable oil (l)} + H_2(g) \xrightarrow[\text{Ni Catalyst}]{60^0\,C} \text{Vanaspathi ghee (s)} \ldots\ldots\ldots\ldots (6)$$

6 . Special information or names of reactants/ products are written below their formulae. For example, copper on reaction with concentrated nitric acid gives reddish coloured poisonous nitrogen di oxide gas.

$$Cu(s) + 4\,HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l) \ldots\ldots\ldots\ldots (7)$$

(Concentrated)

However, on reaction with dilute nitric acid, the product formed is nitric oxide gas.

$$3Cu(s) + 8HNO_3(aq) \longrightarrow 3Cu(NO_3)_2(aq) + 2NO(g) + 4H_2O(l) \ldots\ldots\ldots\ldots (8)$$

(dilute)

Try this.

Apparatus: Test tube, conical flask, balance, etc.
Chemicals : Sodium chloride and silver nitrate.

Procedure :

1. Take sodium chloride solution in a conical flask and silver nitrate solution in a test tube.
2. Tie a thread to the test tube and insert it carefully into the conical flask. Make the conical flask air tight by fitting a rubber cork.
3. Weigh the conical flask with the help of a balance.
4. Now tilt the conical flask and mix the solution present in the test tube with the solution in the conical flask.
5. Weigh the conical flask again.

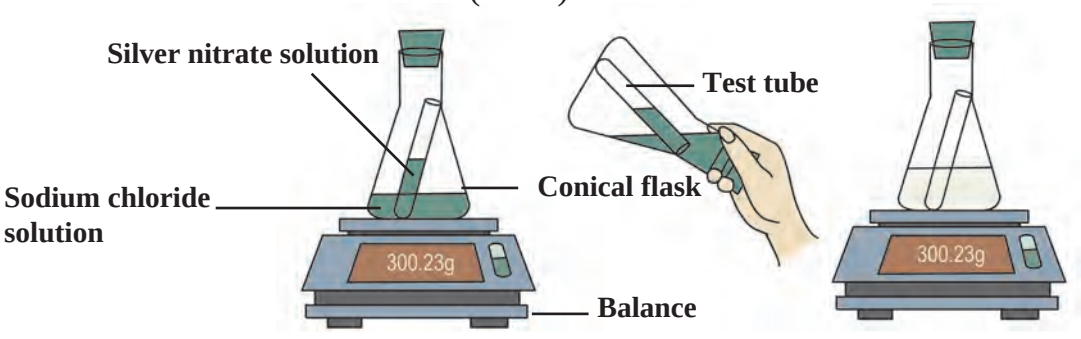
Which changes did you find? Did any insoluble substance form? Was there any change in the weight?

A word equation is written for the above activity as shown below.

Silver nitrate + Sodium chloride ⟶ Silver chloride + Sodium nitrate

The above word equation is represented by the following chemical equation.

$$AgNO_3(aq) + NaCl(aq) \longrightarrow \underset{\text{(white)}}{AgCl\downarrow} + NaNO_3(aq) \ldots\ldots\ldots (9)$$



3.4 The reaction of sodium chloride with silver nitrate

Do you know ? Silver nitrate is used in the voters-ink.

Find out What are the other uses of silver nitrate in everyday life?