7

CHEMICAL BONDING

In lesson 5, you have read about the electronic configuration of atoms of various elements and variation in the periodic properties of elements. We see various substances around us which are either elements or compounds. You also know that atoms of the same or different elements may combine. When atoms of the same elements combine, we get molecules of the elements. But we get compounds when atoms of different elements combine. Have you ever thought why atoms combine at all?

In this lesson, we will find an answer to this question. We will first explain what a chemical bond is and then discuss various types of chemical bonds which join the atoms together to give various types of substances. The discussion would also highlight how these bonds are formed.

The properties of substances depend on the nature of bonds present between their atoms. In this lesson you will learn that sodium chloride, the common salt and washing soda dissolve in water whereas methane gas or napthalene do not. This is because the type of bonds present between them are different. In addition to the difference in solubility, these two types of compounds differ in other properties as well about which you will study in this lesson.

OBJECTIVES

After completing this lesson you will be able to :

- *recognize the stability of noble gas configuration and tendency of other elements to attain this configuration through formation of chemical bonds;*
- *explain the attainment of stable noble gas electronic configuration through transfer of electrons resulting in the formation of ionic bonds;*

- *describe and justify some of the common properties of ionic compounds;*
- *explain the alternate mode of attainment of stable noble gas configuration through sharing of electrons resulting in the formation of covalent bonds;*
- *describe the formation of single, double and triple bonds and depict these with the help of Lewis-dot method;*
- *describe and justify some of the common properties of covalent substances.*

7.1 WHY DO ATOMS COMBINE?

The answer to this question is hidden in the electronic configurations of the noble gases. It was found that noble gases namely helium, neon, argon, krypton, xenon and radon did not react with other elements to form compounds i.e. they were non -reactive. In the initial stages they were also called inert gases due to their non-reactive nature. Thus it was, thought that these noble gases lacked reactivity because of their specific electronic arrangements which were quite stable. When we write the electronic configurations of the noble gases (see table below), we find that except helium all of them have 8 electrons in their outermost shell.

Table 7.1 : Electronic configuration of Noble gases

Name	Symbol	Atomic Number	Electronic Configuration	No. of electrons in the outermost shell
Helium	He	2	2	2
Neon	Ne	10	2,8	8
Argon	Ar	18	2,8,8	8
Krypton	Kr	36	2,8,18,8	8
Xenon	Xe	54	2,8,18,18,8	8
Radon	Ra	86	2,8,18,32,18,8	8

It was concluded that atoms having 8 electrons in their outermost shell are very stable and they did not form compounds. It was also observed that other atoms such as hydrogen, sodium, chlorine etc. which do not have 8 electrons in their outermost shell undergo chemical reactions. They can stabilize by combining with each other and attain the above configurations of noble gases i.e. 8 electrons (or 2 electrons in case of helium) in their outermost shells. Thus, atoms tend to attain a configuration in which they have 8 electrons in their outermost shells. This is the basic cause of chemical bonding. This attainment of eight electrons for stable structure is called the **octet rule**. The octet rule explains the chemical bonding in many compounds.

Atoms are held together in compounds by the forces of attraction which result in formation of **chemical bonds**. The formation of chemical bonds results in the lowering of energy which is less than the energy the individual atoms. The resulting compound is lower in energy as compared to sum of energies of the reacting atom/molecule and hence is more stable. Thus stability of the compound formed is an important factor in the formation of chemical bonds. In rest of the lesson you will study about the nature of bonds present in various substances. We would explain *ionic bonding and covalent bonding in this lesson*. Before you start learning about ionic bonding in the next section you can answer the following questions to check your understanding.

INTEXT QUESTIONS 7.1

1. State octet rule
2. Why noble gases are non-reactive?
3. In the table given below three elements and their atomic numbers are given. Which of them are stable and will not form compound?

Element	At. No.	Stable/Unstable
A	10	
B	36	
C	37	

7.2 IONIC BONDING

The chemical bond formed by transfer of electron from a metal to a non- metal is known as *ionic* or *electrovalent bond*.

For example, when sodium metal and chlorine gas are brought into contact, they react violently and we obtain sodium chloride. This reaction is shown below:

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$

The bonding in sodium chloride can be understood as follows:

Sodium (Na) has the atomic number 11 and we can write its electronics configuration as 2,8,1 i.e. it has one electron in its outermost (M) shell. If it loses this electron, it is left with 10 electrons and becomes positively charged. Such a positively charged ion is called a cation. The cation in this case is called sodium cation, Na^+. This is shown below in Fig. 7.1.

$$\begin{array}{ccccccccc} Na(s) & + & Cl(g) & \longrightarrow & Na^{+} & + & Cl^{-} & \longrightarrow & NaCl(s) \\ 2,8,1 & & 2,8,7 & & 2,8 & & 2,8,8 & & \end{array}$$

Fig. 7.1 *Formation of NaCl*

Note that the sodium cation has 11 protons but 10 electrons only. It has 8 electrons in the outermost (L) shell. Thus, sodium atom has attained the noble gas configuration by losing an electron present in its outermost shell. Loss of electron results into formation of an ion and this process is called *ionization*. Thus, according to octet rule, sodium atom can acquire stability by changing to sodium ion (Na^+).

The ionization of sodium atom to give sodium ion requires an energy of 496 kJ mol^{-1}.

Now, chlorine atom having the atomic number 17, has the electronic configuration 2,8,7. It completes its octet by gaining one electron from sodium atom (at. no. 11) with electronic configuration 2, 8, 1.

Both sodium ion (Na^+) and chloride ion (Cl^-) combine together by ionic bond and become solid sodium chloride (NaCl).

Note that in the above process, the chlorine atom has gained an additional electron hence it has become a negatively charged ion (Cl^-). Such, a negatively charged ion is called an **anion**. Chloride ion has 8 electrons in its outermost shell and it therefore, has a stable electronic configuration according to the octet rule. The formation of chloride ion from the chlorine atom releases 349 kJ mol^{-1} of energy.

Since the **cation** (Na^+) and the **anion** (Cl^-) formed above are electrically charged species, they are held together by Coulombic force or electrostatic force of attraction. This **electrostatic force of attraction which holds the cation and anion together is known as electrovalent bond or ionic bond**. This is represented as follows:

$$Na^{+}(g) + Cl^{-}(g) \longrightarrow Na^{+}Cl^{-} \text{ or } NaCl(s)$$

Note that only outermost electrons are shown above. Such structures are also called **Lewis Structures**.

If we compare the energy required for the formation of sodium ion and that released in the formation of chloride ion, we note that there is a net difference of 147 kJ mol^{-1} of energy. If only these two steps are involved, the formation of sodium chloride is not favourable energetically. But sodium chloride exists as a crystalline solid. This is because the energy is released when the sodium ions and the chloride ions come together to form the crystalline structure. The energy so released compensates for the above deficiency of energy.

You can see that *each sodium ion is surrounded by six chloride ions and each chloride ion is surrounded by six sodium ions* in its solid state structure. The force of attraction between sodium and chloride ions is uniformly felt in all directions. Thus, no particular sodium ion is bonded to a particular chloride ion. Hence, there is no species such as NaCl. Here NaCl is empirical formula and shows that there is one Na^+ for every Cl^- Fig. 7.2.

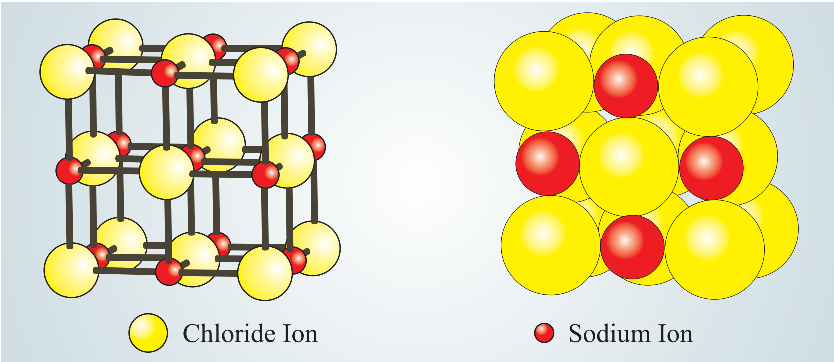


Fig. 7.2 Structure of sodium chloride

Similarly, we can explain the formation of cations resulting from lithium and potassium atoms and the formation of anions resulting from fluorine, oxygen and sulphur atoms.

Let us now study the formation of another ionic compound namely magnesium chloride. Mg has atomic number 12. Thus, it has 12 protons. The number of electrons present in it is also 12. Hence the electronic configuration of Mg atom is 2, 8, 2.

Let us consider the formation of magnesium ion from a magnesium atom. We see that it has 2 electrons in its outermost shell. If it loses these two electrons, then we can achieve the stable configuration of 2, 8 (that of noble gas neon). This can be represented in Fig. 7.3.

$$\underset{2,\,8,\,2}{Mg} \longrightarrow \underset{2,\,8}{Mg^{2+}} + 2e^-$$

Fig. 7.3 Formation of magnesium ion

You can see that the resulting magnesium ion has only 10 electrons and hence it has 2+ charge. It is a dipositive ion and can be represented as Mg^{2+} ion.

The two electrons lost by the magnesium are gained -one each by two chlorine atoms to give two chloride ions.

$$2[Cl(g) + e^- \longrightarrow Cl^-(g)]$$

or

$$2Cl(g) + 2e^- \longrightarrow 2Cl^-(g)$$

Thus, one magnesium ion and two chloride ion join together to give magnesium chloride, $MgCl_2$. Hence we can write as in Fig. 7.4.

$$\underset{2,\,8,\,2}{Mg} + \underset{2,\,8,\,7}{Cl},\ \underset{2,\,8,\,7}{Cl} \longrightarrow Mg^{2+} + 2Cl^- \longrightarrow MgCl_2(s)$$

Fig. 7.4 Formation of magnesium chloride

Let us now see what would happen if instead of chloride ion, the magnesium ion combines with another anion say oxide anion. The oxygen atom having atomic number eight has 8 electrons. Its electronic configuration is 2,6. It can attain a stable electronic arrangement (2,8) of the noble gas neon if it gains two more electrons. The two electrons, which are lost by the magnesium atom, are gained by the oxygen atom. On gaining these two electrons, the oxygen atom gets converted into the oxide anion. This is shown below in Fig. 7.5.

$$\underset{2,\,6}{O} + 2e^- \longrightarrow \underset{2,\,8}{O^{2-}}$$

Fig. 7.5 Formation of oxide ion

The oxide has 2 more electrons as compared to the oxygen atom. Hence, it has 2 negative charges on it. Therefore, it can be represented as O^{2-} ion

The magnesium ion (Mg^{2+}) and the oxide ion (O^{2-}) are held together by electrostatic force of attraction. This leads to the formation of magnesium oxide Fig. 7.6.

$$\underset{2,\,8,\,2}{Mg} + \underset{2,\,6}{O} \longrightarrow \underset{2,\,8}{Mg^{2+}} + \underset{2,\,8}{O^{2-}} \longrightarrow MgO(s)$$

Fig. 7.6 Formation of magnesium oxide

Thus, magnesium oxide is an ionic compound in which a dipositive cation (Mg^{2+}) and a dinegative anion (O^{2-}) are held together by electrostatic force.

Similar to the case of sodium chloride, the formation of magnesium oxide is also accompanied by lowering of energy which leads to the stability of magnesium oxide as compared to individual magnesium and oxygen atoms.

Similarly, the ionic bonding present in many other ionic compounds can be explained. The ionic compounds show many characteristic properties which are discussed below.

7.2.1 Properties of Ionic Compounds

Since the ionic compounds contain ions (cations and anions) which are held together by the strong electrostatic forces of attraction, they show the following general characteristic properties:

(a) Physical State

Ionic compounds are crystalline solids. In the crystal, the ions are arranged in a regular fashion. The ionic compounds are hard and brittle in nature.

(b) Melting and boiling points

Ionic compounds have high melting and boiling points. The melting point of sodium chloride is 1074 K (801°C) and its boiling point is 1686K (1413°C). The melting and boiling points of ionic compounds are high because of the strong electrostatic forces of attraction present between the ions. Thus, it requires a lot of thermal energy to overcome these forces of attraction. The thermal energy given to the ionic compounds is used to overcome the interionic attractions present between the cations and anions in an ionic crystal. Remember that the crystal has a three dimensional regular arrangement of cations and anions which is called **crystal lattice**. On heating, the breaking of this crystal lattice leads to the molten state of the ionic compound in which the cations and anions are free to move.

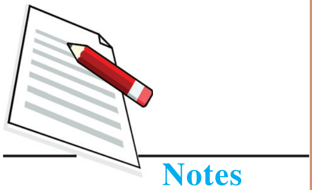
(c) Electrical Conductivity

Ionic compounds conduct electricity in their molten state and in aqueous solutions. Since ions are free to move in the molten state, they can carry current from one electrode to another in a cell. Thus ions can conduct electricity in molten state. However, in solid state, such a movement of ions is not possible as they occupy fixed positions in the crystal lattice. Hence in solid state, ionic compounds do not conduct electricity.

In aqueous solution, water is used as a solvent to dissolve ionic compounds. It weakens the electrostatic forces of attraction present among the ions. When these forces are weakened, the ions become free to move, hence they can conduct electricity.

ACTIVITY 7.1

Prepare a solution of NaCl by dissolving 1 tablespoon of it in 100 mL water. Take this solution in a 200 mL beaker and introduce two graphite electrode (obtained from used dry cell battery), Now connect the electrode with a 3 V dry cell and a bulb in a circuit as shown in Fig. 7.7. Initially take plane water in a beaker (200 mL) and see the glow of bulb. Now replace the plane water by the solution of NaCl, what difference in glow of the bulb is observed? Interpret the result on the basis of ionic bond you have just studied.



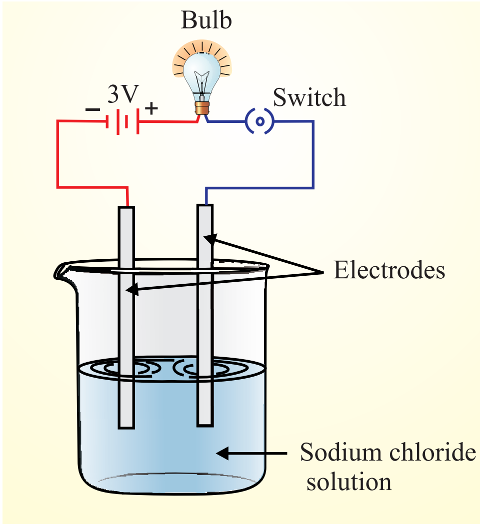


Fig. 7.7 Aqueous solution of sodium chloride conducts electricity

(d) Solubility

Ionic compounds are generally soluble in water but are insoluble in organic solvents such as ether, alcohol, carbon tetrachloride etc. However, a few ionic compounds are insoluble in water due to strong electrostatic force between cation and anion. For example barium sulphate, silver chloride and calcium fluoride.

ACTIVITY 7.2

Take nearly 10 g of NaCl, and two boiling tubes. In boiling tube (1) take 10 mL of water and add nearly 4 g of powdered NaCl. In test tube (2) take nearly 10 mL of ethyl alcohol and add nearly 4 g of powered NaCl. Shake both the test tube vigorously and see change in the amount of NaCl added in each case Fig. 7.8. Write your observation

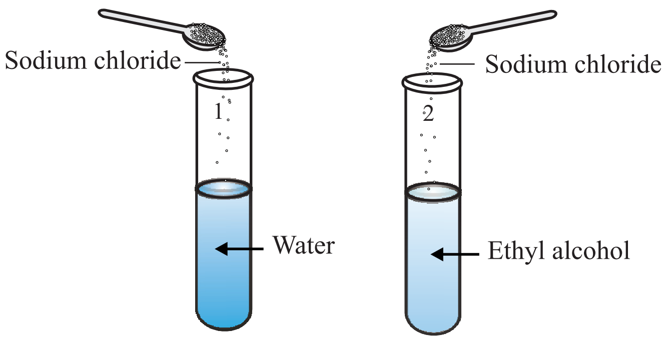


Fig. 7.8 *Showing solubility of NaCl in water and ethyl alcohol*

Before proceeding to the next section in which covalent bonding is discussed, why don't you answer the following questions to test your understanding about the ionic bonding?

INTEXT QUESTIONS 7.2

1. Name the two types of ions present in NaCl.
2. How many shells are present in Na^+ ion?
3. What is the number of electrons present in Cl^- ion?
4. Name the type of force of attraction present in ionic compounds.
5. In sodium chloride lattice, how many Cl^- ions surround each Na^+ ion?
6. Show the formation of Na_2O, $CaCl_2$ and MgO.
7. Why NaCl is bad conductor of electricity in solid state?

7.3 COVALENT BONDING

In this section, we will study about another kind of bonding called *covalent bonding*. Covalent bonding is helpful in understanding the formation of molecules. In lesson 2, you studied that molecules having similar atoms such as H_2, Cl_2, O_2, N_2 etc. are molecules of elements whereas those containing different atom like HCl, NH_3, CH_4, CO_2 etc. are molecule of compounds. Let us now see how are these molecules formed?

Let us consider the formation of hydrogen molecule (H_2). The hydrogen atom has one electron. It can attain the electronic configuration of the noble gas helium by sharing one electron of another hydrogen atom. When the two hydrogen atoms come closer, there is an attraction between the electrons of one atom and the proton of another and there are repulsions between the electrons as well as the protons of the two hydrogen atoms. In the beginning, when the two hydrogen atoms approach each other, the potential energy of the system decreases due to the force of attraction. (Fig. 7.9) The value of potential energy reaches a minimum at some particular distance

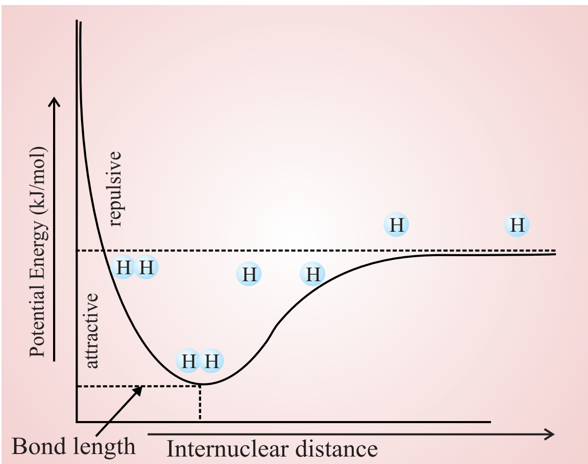


Fig. 7.9 *Potential energy diagram for formation of a hydrogen molecule*

between the two atoms. If the distance between the two atoms further decreases, the potential energy increases because of the forces of repulsion. **The covalent bond forms when the forces of attraction and repulsion balance each other and the potential energy is minimum.** It is this lowering of energy which leads to the formation of the covalent bond.

Formation of covalent bond in H_2 can be shown as

$$H\cdot + \cdot H \longrightarrow H : H \longrightarrow H_2$$

We will next consider the formation of chlorine molecule (Cl_2). A molecule of chlorine contains two atoms of chlorine. Now how are these two chlorine atoms held together in a chlorine molecule?

You know that the electronic configuration of Cl atom is 2,8,7. Each chlorine atom needs one more electron to complete its octet. If the two chlorine atoms share one of their electrons as shown below, then both of them can attain the stable noble gas configuration of argon.

:C̤̈l·	+	·C̤̈l:	$\xrightarrow[\text{one electron}]{\text{sharing of}}$	:C̤̈l : C̤̈l:
chlorine atom 2, 8, 7		chlorine atom 2, 8, 7		shared electrons

Note that the sharing pair of electrons is shown to be present between the two chlorine atoms. Each chlorine atom thus acquires 8 electrons. The shared pair of electrons keeps the two chlorine atoms bonded together. *Such a bond, which is formed by sharing of electrons between the atoms is called a* ***covalent bond****.* Thus, we can say that a covalent bond is present between two chlorine atoms. This bond is represented by drawing a line between the two chlorine atoms as follows:

:C̤̈l – C̤̈l:

covalent bond

Sometimes the electrons shown above on the chlorine atoms are omitted and the chlorine-chlorine bond is shown as follows:

Cl — Cl

Similarly, we can understand the formation of oxygen molecule (O_2) from the oxygen atoms. The oxygen atom has atomic number 8. It has 8 protons and also 8 electrons. The electronic configuration of oxygen atoms is 2,6. Now each oxygen atom needs two electrons to complete its octet. The two oxygen atoms share two electrons and complete their octet as is shown below:

:Ö:	+	:Ö:	$\longrightarrow$	:Ö::Ö:
oxygen atom 2, 6		oxygen atom 2, 6		sharing of 4 electrons or 2 pairs of electrons

The 4 electrons (or 2 pairs of electrons) which are shared between two atoms of oxygen are present between them. Hence these two pairs of shared electrons can be represented by two bonds between the oxygen atoms. Thus, an oxygen molecule can be represented as follows:

$$:\ddot{O}=\ddot{O}:$$

The two oxygen atoms are said to be bonded together by two covalent bonds. Such a bond consisting of two covalent bonds is also known as a **double bond.**

Let us next take the example of nitrogen molecule (N_2) and understand how the two nitrogen atoms are bonded together. The atomic number of nitrogen is 7. Thus it has 7 protons and 7 electrons present in its atom. The electronic configuration can be written as 2,5. To have 8 electrons in the outermost shell, each nitrogen atom requires 3 more electrons. Thus, a sharing of 3 electrons each between the two nitrogen atoms is required. This is shown below:

:N⁝	+	⁝N:	⟶	:N⁝ ⁝N:
nitrogen atom electronic configuration (2, 5)		nitrogen atom electronic configuration (2, 5)		(2, 8) (2, 8) sharing of 6 electrons or 3 pairs of electrons

Each nitrogen atom provides 3 electrons for sharing. Thus, 6 electrons or 3 pairs of electrons are shared between the two nitrogen atoms. Hence, each nitrogen atom is able to complete its octet.

Since 6 electrons (or 3 pairs of electrons) are shared between the nitrogen atoms, we say that three covalent bonds are formed between them. These three bonds are represented by drawing three lines between the two nitrogen atoms as shown below:

$$:N\equiv N:$$

Such a bond which consists of three covalent bonds is known as a **triple bond**. So far, we were discussing covalent bonds formation between atoms of the same elements. But covalent bonds can be formed by sharing of electrons between atoms of different elements also. Let us take the example of HCl to understand it.

A hydrogen atom has one electron in its outermost shell and a chlorine atom has seven electrons in its outermost shell. Each of these atoms has one electron less than the electronic configuration of the nearest noble gas. If they share one electron pair, then hydrogen can acquire two electrons in its outer most shell whereas chlorine will have eight electrons in its outermost shell. The formation of HCl molecule by sharing of one electron pair is shown below:

H·	+	·C̤̈l:	⟶	H : C̤̈l:
hydrogen atom electronic configuration (1)		chlorine atom electronic configuration (2, 8, 7)		shared electron pair

Similarly, we can explain bond formation in other covalent compounds.

After knowing the nature of bonding present in covalent compounds, let us now study what type of properties these covalent compounds have.

7.3.1 Properties of Covalent Substances

The covalent compounds consist of molecules which are electrically neutral in nature. The forces of attraction present between the molecules are less strong as compared to the forces present in ionic compounds. Therefore, the properties of the covalent compounds are different from those of the ionic compounds. The characteristic properties of covalent compounds are given below:

(a) Physical State

Because of the weak forces of attraction present between discrete molecules, called intermolecular forces, the covalent compounds exist as a gas or a liquid or a solid. For example O_2, N_2, CO_2 are gases; water and CCl_4 are liquids and iodine is a solid.

(b) Melting and Boiling Points

As the forces of attraction between the molecules are weak in nature, a small amount of energy is sufficient to overcome them. Hence, the melting points and boiling points of covalent compounds are lower than those of ionic compounds. For example, melting point of nephthalene which is a covalent compound is 353 K (80°C). Similarly, the boiling point of carbon tetrachloride which is another covalent liquid compound is 350 K (77°C).

(c) Electrical Conductivity

The covalent compounds contain neutral molecules and do not have charged species such as ions or electrons which can carry charge. Therefore, these compounds do not conduct electricity and are called poor conductors of electricity Fig. 7.10.

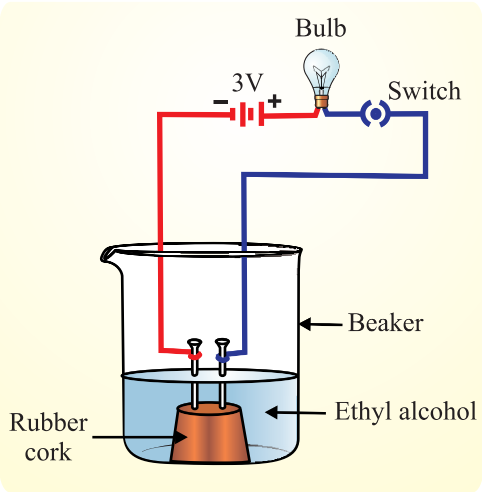


Fig. 7.10 *Ethyl alcohol (a covalent compound) is non-conductor of electricity*

(d) Solubility

Covalent compounds are generally not soluble in water but are soluble in organic solvents such as alcohol, chloroform, benzene, ether etc.

ACTIVITY 7.3

Take about 5 mL of ethyl alcohol in a test tube. Add few crystal of iodine. Shake the test tube well. What do you find. The colour of the ethyl alcohol becomes dark brown. What inference you draw from this. Iodine is soluble in ethyl alcohol. Write your observation. Dissolve the same amount of iodine in the same volume of water. (Soluton of iodine in ethyl alcohol is popularly known as tincture iodine and is used as a antiseptic solution.)

After understanding the nature of covalent bond and properties of covalent compounds. Why don't you answer the following questions to test your understaning about the covalent bonding.

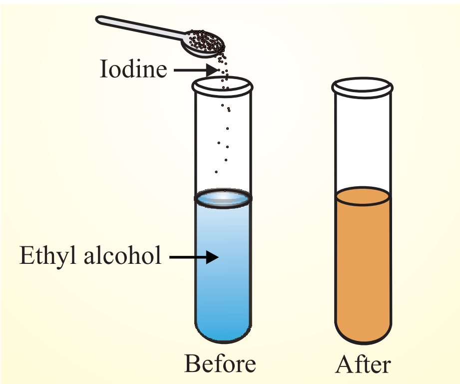


Fig. 7.11 *Showing solubility of iodine in ethyl alcohol*

INTEXT QUESTIONS 7.3

1. How covalent bonds are formed?
2. Show the formation of O_2, HCl, Cl_2 and N_2.
3. How many covalent bond(s) is/are present in following compounds:
   (i) H_2O (ii) HCl (iii) O_2 (iv) N_2
4. State loss or gain of elactrons (giving their number) in the following changes :
   (i) $N \longrightarrow N^{3-}$ (ii) $Cl \longrightarrow Cl^-$
   (iii) $Cu \longrightarrow Cu^{2+}$ (iv) $Cr \longrightarrow Cr^{3+}$
5. Why ethyl alcohol is bad conductor of electricity in its aqueous solutions?

WHAT YOU HAVE LEARNT

- The basic cause of chemical bonding is to attain noble gas configuration either by transfer of electron from a metal to non- metal or by sharing of electrons between two non-metal atoms.
- Atoms of elements don't exist freely in the nature. In all, the atoms of all the elements except of noble gases , have less than eight electrons in the valence shell. Normally gases do not react with other elements in normal conditions as they have stable electronic configuration i.e. they have eight electrons in the valence shell or outer most shell.
- All the atoms have a tendency to acquire stable state or noble gas configuration. Therefore, they combine with atoms of other elements to acquire 08 electrons in the valence shell by giving , taking or sharing of electrons. This is the basic cause of Chemical bonding and is called **Octet Rule.**
- Atoms of elements in a molecule are held together by **Chemical Bonding.** The formation of chemical bonds result in the lowering of energy which is less than the energy of the individual atoms. The resulting compound is lower in energy and hence more stable.
- There are two types of chemical bonding : ionic bonding and covalent bonding.
- Ionic Bonding: The chemical bond formed by transfer of electrons from a metal to a non- metal is known as Ionic Bond or Electrovalent bond.
- The ionic bond formation takes place in three steps.
  - (i) Formation of Cations by metals with loss of electrons.
  - (ii) Formation of Anions by non- metal with gain of electrons.
  - (iii) Combination of Cations and Anions by electrostatic force of attraction to form Ionic bond
- Ionic compounds are solid, hard, have high melting and boiling points. They are soluble in water but insoluble in organic solvents .They are good conductor of electricity in molten state and in aqueous solution.
- Covalent Bonding: The chemical bond formed by mutual sharing of equal no. of electrons between two atoms. Covalent bonding is helpful in understanding the formation of the molecules.H_2, Cl_2, O_2 and N_2 are such molecules formed by sharing of electrons between similar atoms, while H_2O and HCl compounds formed by sharing of electrons between dissimilar atoms.
- On the basis of sharing of number of electrons by each atom, covalent compounds are classified as single bonded, double bonded and triple bonded. When sharing of one electron takes place from both the atoms , single bond is formed. Like Cl-Cl or Cl_2 and H-H or H_2.

- Double bond is formed when two similar atoms share two pair of electrons e.g. O=O or O_2 and triple bond is formed when there is sharing of three electrons from each atom. e.g. N≡N or N_2.
- The dissimilar atoms also share electrons but shared pair of electrons shift towards more reactive atom as in HCl and H_2O.
- Covalent compounds mostly have liquid or gaseous state. Some are solid also. They have low melting point, low boiling point. They are insoluble in water but soluble in organic compounds. They are non- conductor of electricity.

TERMINAL EXERCISE

1. Why ionic compounds conduct electricity in aqueous solution?
2. Covalent compounds have low melting point than an ionic compound why?
3. Explain the formation of Na^+ ion from Na atom.
4. How would you explain the bonding in $MgCl_2$?
5. Which of the following statements are correct for ionic compounds:
   (i) They are insoluble in water.
   (ii) They are neutral in nature.
   (iii) They have high melting points.
6. State three characteristic properties of ionic compounds.
7. How does a covalent bond form?
8. What is the number of solvent bonds present in the following molecules?
   (i) Cl_2 (ii) N_2 (iii) O_2 (iv) H_2
9. Classify the following statements as true or false:
   (i) Ionic compounds contain ions which are held together by weak electro-static forces.
   (ii) Ionic compounds have high melting and boiling points.
   (iii) Covalent compounds are good conductors of electricity.
   (iv) Solid sodium chloride is a good conductor of electricity.
10. Classify the following compounds as ionic or covalent:
    (i) sodium chloride (ii) calcium chloride
    (iii) oxygen (iv) hydrogen chloride
    (v) magnesium oxide (vi) nitrogen

11. An element 'X' has atomic no. 11 and 'Y' has atomic no. 8. What type of bond they will form? Write the formula of the compound formed by reacting X and Y.

12. Name the type of bonds present in H_2O molecule.

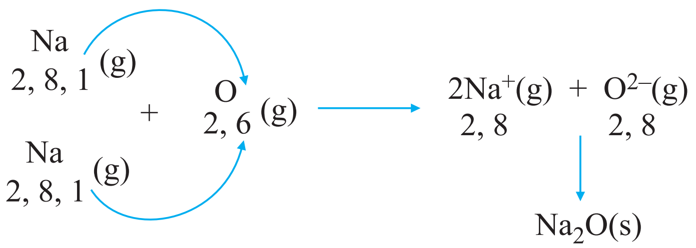
ANSWER TO INTEXT QUESTIONS

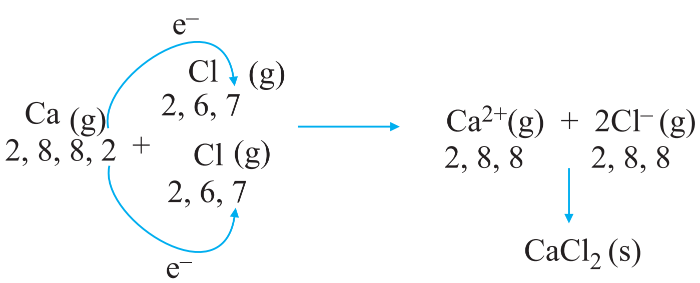
7.1

1. Every atom has tendency to attain 2 or 8 e^- in their outermost shell to get stability like noble gases.
2. Because they have inert gas configuration which makes it very stable.
3. A and B

7.2

1. Sodium ion Na^+ and chloride ion Cl^-.
2. Two (2)
3. 18
4. Electrostatic force of attraction
5. Six
6.





$$\underset{2,\,8,\,2}{Mg\,(g)} + \underset{2,\,6}{O\,(g)} \longrightarrow \underset{2,\,8}{Mg^{2+}(g)} + \underset{2,\,8}{O^{2-}(g)}$$

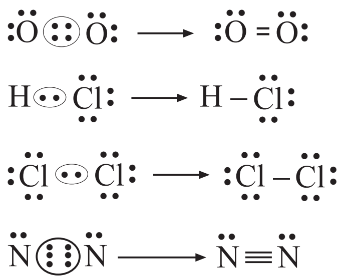
$$\downarrow$$

$$MgO\,(s)$$

7. Due to absence of free Na^+ and Cl^- ion.

7.3

1. A covalent bond is formed by sharing of equal no. of electrons between two atoms.

2. 

3. (i) 2 (ii) 1 (iii) 2 (iv) 3

4. (i) Gain of $3e^-$
   (ii) Gain of $1e^-$
   (iii) Loss of $2e^-$
   (iv) Loss of $3e^-$

5. Ethyl alcohol do not produce H^+ ion in its aqueous solution, hence does not conduct electricity.