Chapter 4

CHEMICAL BONDING

Time Allocation

Teaching periods	= 14
Assessment period	= 4
Weightage	= 14

Major Concepts

4.1 Why do atoms form chemical Bonds?
4.2 Formation of Chemical Bonds.
4.3 Types of Bonds.
4.4 Intermolecular Forces.
4.5 Nature of Bonding and Properties.

STUDENTS LEARNING OUTCOMES (SLO'S)

Students will be able to:

- Find the number of valence electrons in an atom using the Periodic Table.
- Describe the importance of noble gas electronic configurations.
- State the octet and duplet rules.
- Explain how elements attain stability.
- Describe the ways in which bonds may be formed.
- State the importance of noble gas electronic configurations in the formation of ion.
- Describe the formation of cations from an atom of a metallic element.
- Describe the formation of anions from an atom of a non-metallic element.
- Describe the characteristics of an ionic bond.
- Recognize a compound as having ionic bonds.
- Identify characteristics of ionic compounds.
- Describe the formation of a covalent bond between two non metallic elements.
- Describe with examples single, double and triple covalent bonds.
- Describe the properties of polar and non-polar compounds.
- Draw electron cross and dot structures for simple covalent molecules containing single, double and triple covalent bonds.
- Describe the weak forces of interaction such as dipole-dipole interaction and hydrogen bonding.

INTRODUCTION:

In the previous chapter, you have learnt about the matter. You are also familiar with the fact that all the matters in this world are composed of atoms. The attractive force which binds atoms together is called as a chemical bond or chemical forces. Few elements also consist of un-bounded atoms. For instance, helium, neon, argon, xenon and krypton present in the atmosphere consist of un-bounded atoms. The way in which various atoms are bonded together has a effect on the properties of substances.

In this chapter, we will explore the nature of various types of chemical bonding.

4.1 WHY DO ATOMS FORM CHEMICAL BOND?

Why do atoms form chemical bonds? The essential answer is that everyone in the world desires to be stable in their life. Atoms are just like that, they are also trying to become more stable, so atom try to shares required number of electrons with each other to obtain the electronic configurations of noble gases.

Electronic Configuration of Noble Gas

Noble gases have $ns^{2,}$ np^{6} electronic configuration in the outermost shell and rarely form chemical bonds. The noble gases are Helium (He), Neon (Ne), Argon (Ar), Krypton (Kr), Xenon (Xe) and Radon (Rn). These elements are sometimes called the inert gases. This is because they do not participate in chemical reactions. Outer shell of five noble gas atoms are shown in figure 4.1

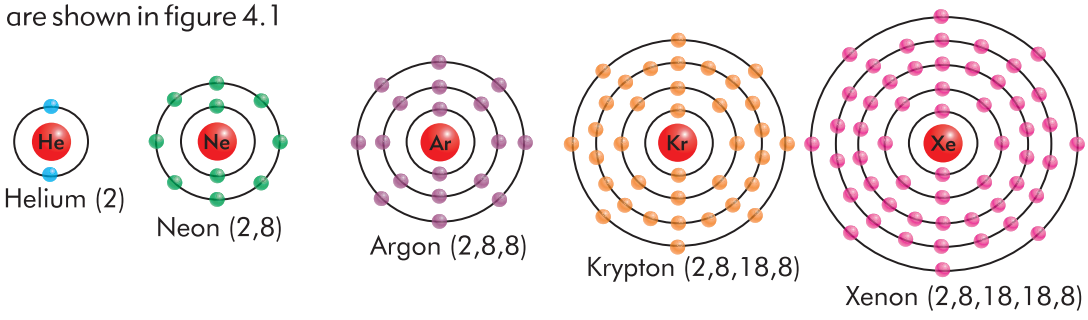


Figure: 4.1 Outer electronic configuration of the noble gases

Note that Helium contains 2 electrons and other noble gases contain 8 electrons in the valence shell. Because of these electronic configurations noble gases are stable and not active. Atoms to acquire two electrons in the valence shell is called duplet rule, whereas atoms to acquire eight electrons in the valence shell is called the octet rule. In 1916 a chemist G.N. Lewis used this fact, why atoms undergo chemical reactions. He called his explanation as octet rule. An octet means a set of eight.

What are valence electrons?

Electrons present in the outermost shell of any atom play an important role in determining the chemical properties of the atom, including its ability to form chemical bonds. These electrons in the outermost shell of an atom are called as valence electrons or outer electrons. Finding of valence electron or the electron configuration consider an example of Boron (B), it has electronic number five. The electronic configuration looks like this: $1s^2$, $2s^2$, $2p^1$ since there are three electrons in the second shell ($2s^2$ and $2p^1$), we can say boron has three valence electrons. The valence electrons which are involved in chemical bonding are termed as bonding electrons.

In the chapter 3, you have learned that the group number indicates the number of valence electrons in an atom. For example, sodium belongs to group IA, so it contains one electron in its valence shell. Similarly, phosphorus belongs to group VA, so it contains five electrons in the valence shell.

Test Yourself

- Why an atom form chemical bond?
- When atoms are considered to be unstable?
- Why doesn't helium atom tend to gain electron?
- Where are valence electrons located, and why are they important?
- What is meant by bonding electrons?
- Write the electronic configuration of Ne (atomic No. 10),Carbon (atomic No. 6) and sulphur (atomic No. 16).
- Why, noble gases do not react with other element to form compounds?
- Find the number of valence electrons in the following atoms.
  (a) Chlorine (b) Sodium
  (c) Magnesium (d) Potassium

4.2 FORMATION OF CHEMICAL BOND

Chemical bonding is the combining of atoms to form new substances. An interaction that holds two atoms together is called a chemical bond. Atoms can lose, gain or share valence electrons to form chemical bonds.

4.3 TYPES OF CHEMICAL BONDS

There are three types of bonds depending on the tendency of an atom to lose or gain or share electrons.

1. Ionic Bond
2. Covalent Bond
3. Co-ordinate covalent bond or dative covalent

4.3.1 Ionic Bonds

In the formation of ionic bond, an atom loses electrons and changes into positive ion (cation). Whereas another atom gains electron and changes into negative ion (anion). These cations and anions have opposite charges. They attract one another by electrostatic force of attraction. The electrostatic force of attraction that holds the oppositely charged ions together is called as ionic bond or electrovalent bond.

Generally, ionic bond is formed between the atoms of two different groups, metal and non-metal. Compounds that contain ionic bonds are called ionic compounds. Such as sodium chloride, potassium chloride, magnesium fluoride etc.
Formation of ionic bond is explained in following examples.

Example 1:

The Reaction between Sodium and Chlorine

Sodium atom is a metal of IA group of the periodic table and has only one electron in the outer most shell. The electron arrangement of sodium atom is 2, 8, 1. By losing one electron from the outer most shell, sodium forms cation (Na^+). Whereas chlorine atom is non-metal of VIIA group and has seven electrons in its outermost shell. The electron arrangement of chlorine atom is 2, 8, 7. Since chlorine atom has seven electrons in its outermost shell, it needs one electron to complete octet. By gaining one electron, chlorine atom now has eight electrons in its outermost shell and a chloride ion is formed (Cl^-).

$$Na \rightarrow Na^+ + e^-$$
$$2, 8, 1 \qquad 2, 8$$
$$Cl + \bar{e} \rightarrow Cl^-$$
$$2, 8, 7 \qquad 2, 8, 8$$

(Sodium chloride)

Both these atoms are now oppositely charged ions. Therefore two charged ions are attracted to each other by electrostatic force of attraction. Thus Na^+ and Cl^- ions are joint by ionic bond and form sodium chloride. The formation of ionic bonds by a 'dot and cross' diagram is shown in figure 4.2.

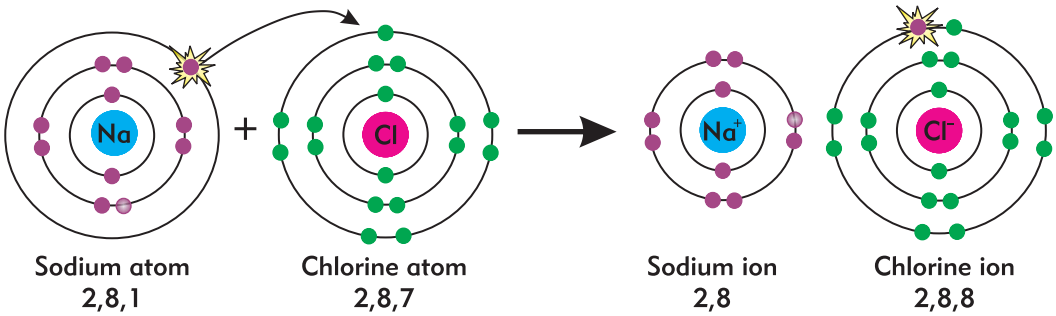


Fig 4.2 Formation of ionic bond in Sodium chloride

Example 2:

The Reaction between Magnesium and Oxygen

Consider another example of ionic bond formation is the reaction between magnesium and oxygen forming magnesium oxide. Magnesium is in IIA group of the periodic table and has only two electrons to share and oxygen is in group VIA and has six electrons in its outermost shell. By losing two electrons from the outermost shell, magnesium becomes Mg^{2+} and it is left with 8 electrons in the second shell. By gaining two electrons, oxygen atom now also has eight electrons in its outermost shell and becomes O^{2-}.Both these atoms are now changed into oppositely charged ions. The attraction between the oppositely charged ions forms the ionic bond between magnesium and oxygen. The formula of magnesium oxide is MgO. The formation of ionic bonds by a 'dot and cross' diagram is shown in figure 4.3.

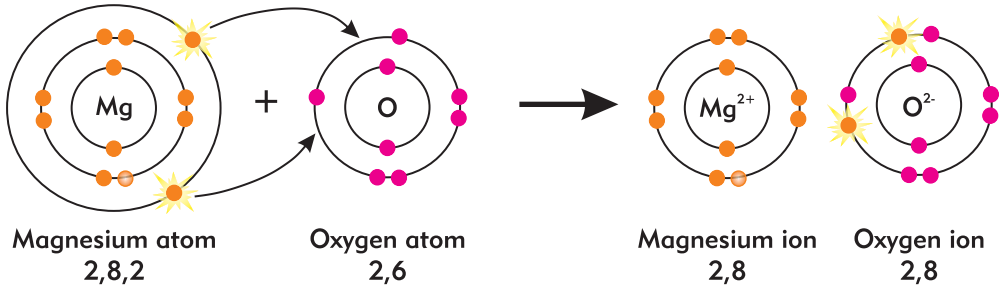


Fig 4.3 Formation of ionic bond in Magnesium oxide

The ionic bond between magnesium and oxygen is stronger than the ionic bond between sodium and Chlorine because of the greater charge density on the ions. Magnesium oxide has a higher melting point due to the presence of the stronger bond.

Do You Know?

- The alkali metals (IA group elements) lose a single electron to form a monovalent cation.
- The alkaline earth metals (IIA group elements) lose two electrons to form di valent cation (M^{++}).
- Aluminum, a member of the IIIA family, loses three electrons and form tri valent cation (M^{+++}).
- The halogens (VIIA group elements) have seven valence electrons. All the halogens gain one electron to complete their octet. And all of them form an anion with a single negative charge.
- The VIA elements gain two electrons and form di valent anions (eg O^{2-}, S^{2-})
- The VA elements gain three electrons and form tri valent anions (eg N^{3-}, P^{3-})

4.3.2 Covalent Bond

In this type of bond, electrons are not gained or lost by atoms. A covalent bond is formed by mutual sharing of electrons between two atoms. This type of bonding occurs between two atoms of the same element or atoms of different elements. This bonding occurs primarily between nonmetals; however, it can also be observed between metals and non-metals.

Consider the formation of covalent bond between two hydrogen atoms. Hydrogen has one electron in their valence shell. When two hydrogen atoms share their valence electrons, both atoms achieve the electronic configuration of noble gas and satisfy the duplet rule.

A covalent bond is generally represented by a short straight line (–) between two bonded atoms. Figure 4.4 shows the formation of a covalent bond by a 'dot' and 'cross' diagram.

Do You Know?

When there is one electron in a sub-orbital, it is called an unpaired electron. When the sub-orbital is filled with a maximum of two electrons, it is called an electron pair. The electron pairs can be found in two types as bond pair and lone pair.

The main difference between bond pair and lone pair is that bond pair is composed of two electrons that are in a bond whereas lone pair is composed of two electrons that are not in a bond.

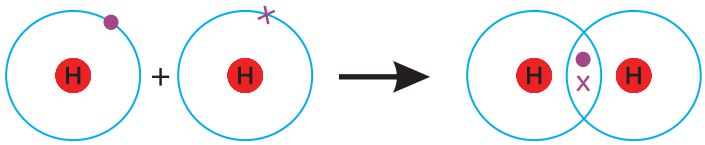


Fig 4.4 The formation of a hydrogen molecule

Types of Covalent Bond

As we know that the covalent bond is formed by mutual sharing of electrons between two atoms. The electrons of atoms that pair up to form a chemical bond are called bond pair electrons. Depending upon the number of bond pair, a covalent bond is further classified into three types.

- Single Covalent Bond
- Double Covalent Bond
- Triple Covalent Bond

Single Covalent Bond (–)

A covalent bond which is formed by the mutual sharing of one bond pair is called a single covalent bond and it is represented by a single short straight line. The formations of H-H, H-Cl, CH_4 are few examples of this type of bonding. Below figure shows the formation of chlorine molecule by a dot and cross diagram.

Formation of Chlorine Molecule

A chlorine atom belongs to group VIIA and it has seven outer electrons. It needs one more electron to achieve a stable octet electronic configuration. When two chlorine atoms share their valence electrons, both atoms achieve the electronic configuration of noble gas. The single bond in chlorine molecule is represented by a dot and cross diagram as shown in figure 4.5.

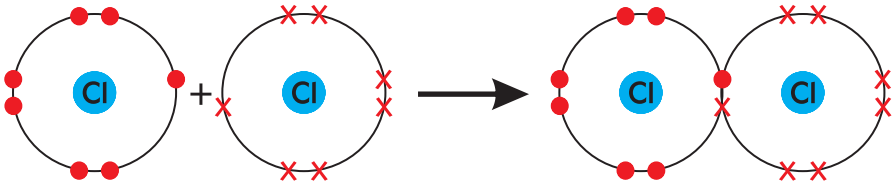


Fig 4.5 Formation of single covalent bond in chlorine molecule

Some other examples of formation of single covalent bond in hydrogen chloride and methane can be represented as follows:

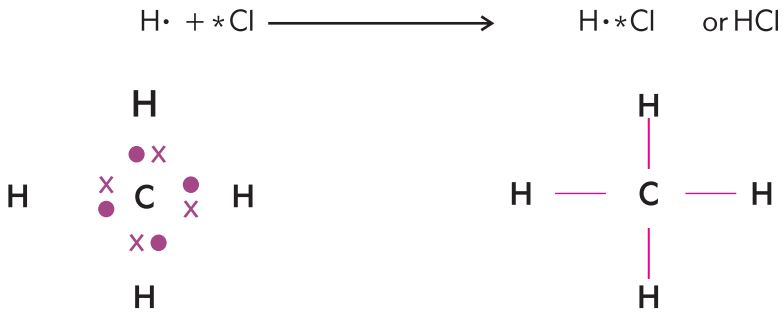


Fig 4.6 Formation of single covalent bond in hydrogen chloride and methane

Double Covalent Bond (═)

A covalent bond which is formed by the mutual sharing of two bond pairs called a double covalent bond and it is represented by two short straight lines. The examples of molecules having double bonds are oxygen (O_2) and ethene (C_2H_4).

Formation of Oxygen Molecule

Oxygen atom belongs to group VIA of the periodic table and it has 6 valence electrons in its outer shell. It needs two more electrons to achieve a stable octet electronic configuration. Each oxygen atom will share two of its outer electrons with another oxygen atom to form an oxygen molecule (O_2).Thus, two pair of electrons are shared between the two oxygen atoms to form a double covalent bond. The double covalent bond in an oxygen molecule is represented by a dot and cross diagram as shown in figure 4.7

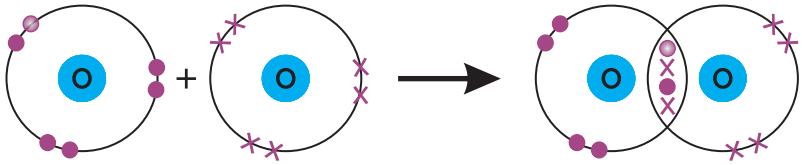
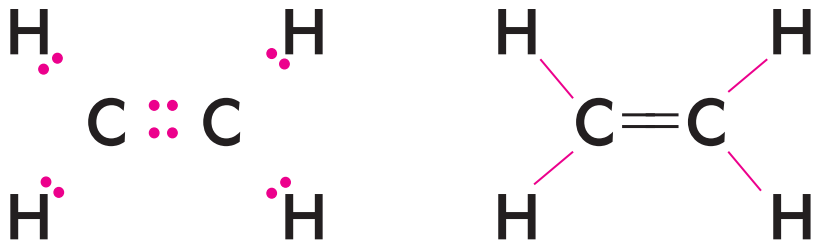


Fig 4.7 Formation of double covalent bond in oxygen molecule

The structural formula of an oxygen molecule is written

Another example of double covalent bond in ethene molecule can be represented as follows:



Triple Covalent Bond (≡)

A covalent bond which is formed by the mutual sharing of three bond pairs is called a triple covalent bond and it is represented by three short straight lines. For example, Molecule of nitrogen (N≡N) and ethyne (CH≡CH).

Formation of Nitrogen Molecule

Nitrogen is a non-metal. Each nitrogen atom has five electrons in its outer shells. Two nitrogen atoms will share three electrons to form three covalent bonds which is called triple covalent bond and form a nitrogen molecules (N_2). The triple bond in nitrogen molecule is represented by dot and cross diagram shown in figure 4.8

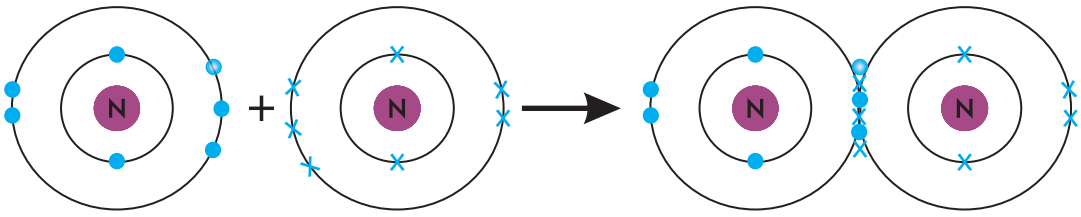


Fig 4.8 Formation of triple covalent bond in nitrogen molecule

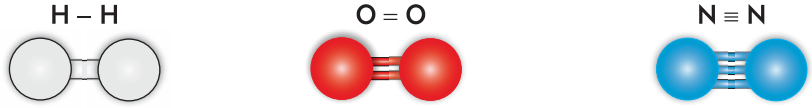
The structural formula of a nitrogen molecule is:

$$N \equiv N$$

Another example of triple covalent bond in ethyne molecule can be represented as follows:

Thus, we can simply define three types of covalent bond as:

- Mutual sharing of two electrons between two atoms form a single covalent bond.
- Mutual sharing of four electrons between two atoms form a double covalent bond.
- Mutual sharing of six electrons between two atoms form a triple covalent bond.



Single bond | Double bond | Triple bond

4.3.3 Polar and Non-polar Covalent Bond

Covalent bonds are formed between two similar and dissimilar atoms.

For example, H - H, O = O, N ≡ N, H - Cl

Non-polar Covalent Bond

The covalent bond formed between identical atoms is called non-polar covalent bond. Both the identical atoms exert same force on the shared electron pairs. Non polar covalent bond in hydrogen molecule is shown below:

In the above example, each H atom has same electro negativity value of 2.1, therefore the covalent bond between them is considered as non-polar.

It means non-polar covalent bonds are formed when the electro negativities of the two atoms are equal.

Polar Covalent Bond

On the other hand, when different atoms share electron pair, both the atoms exert unequal forces on the shared electron pair. Such a covalent bond is called a polar covalent bond. For example, bond in HCl, H_2O, NH_3 are polar covalent bonds.

In the formation of polar covalent bond, one of the atoms will attract the shared electron pair more strongly than the other one. This atom will be called more electronegative atom. So, the more electronegative atom partially draws electron towards itself, this make it partially negatively charged δ^- and another atom partially positively charged δ^+.

For example, in Hydrogen chloride, Cl is more electronegative than the hydrogen. This causes the Cl atom to acquire a slight negative charge, and H atom aquire a slight positive charge due to electronegative difference. Thus, the bond between hydrogen and chlorine is called a polar covalent bond.

The compounds which have polar covalent bonds are called polar compounds.

Electronegative values determine whether a chemical bond will be ionic or covalent in nature. When the difference between electronegative values of two bonded atoms is more than 1.7, the bond will be purely ionic or electrovalent, whereas the difference is less than 1.7, the bond will be covalent. If the electronegative difference of bonded atoms is zero, the bond will be pure covalent or non-polar.

Do You Know?

Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons.

Fluorine (the most electronegative element) is assigned a value of4.0, and values range down to cesium and francium which are the least electronegative at 0.7.

4.3.4 Coordinate Covalent Bond or Dative Covalent Bond

In the previous topic we have learned each atom contributes electron to form a covalent bond. However, covalent bond can be formed between two atoms even when only one of the atoms contributes both electrons constituting the covalent bond. Such a bond is called as a coordinate covalent bond or dative bond. Thus, we can define a coordinate covalent bond as:

The type of bond in which bond pair of electrons is contributed by one atom only, is called coordinate covalent or dative covalent bond.

Concept of donor and acceptor

The atom that donates the electron pair is called the donor and the other atom which accepts the electron pair is called acceptor. A coordinate covalent bond is represented by an arrow (→) pointing towards the atom which accepts the electron pair. A few examples of formation of a coordinate covalent bond are given as under:

Reaction between Ammonia and Hydrogen Chloride

The reaction between ammonia and hydrogen chloride involves the formation of a dative bond between N atom in NH_3 containing lone pairs and H^+ ion from HCl. When ammonia reacts with hydrogen ions (H^+) in an aqueous solution of an acid, the hydrogen ion is attracted to the lone pair and a coordinate covalent bond is formed.

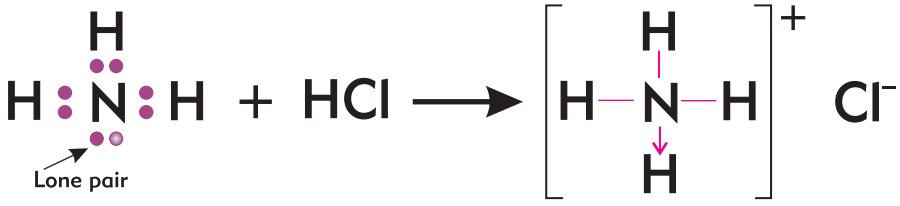
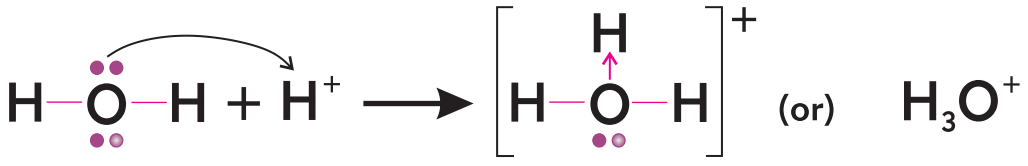


Fig 4.9 Reaction between Ammonia and Hydrogen Chloride

When hydrogen chloride dissolves in water, hydrogen ion is attracted to the lone pair of electrons which is available on oxygen and hydronium ion is formed as shownbelow:



Once a bond is formed, it is impossible to tell any difference between the dative covalent and ordinary covalent bonds. There is no difference between them in reality. The only difference between the two is a mode of formation. Due to their covalent nature of bond formation, the properties of these compounds are similar to those of covalent compounds.

Metallic Bond

Metallic bonds are formed by the attraction between metal ions and delocalized or "mobile" electrons within metal as shown in figure 4.10

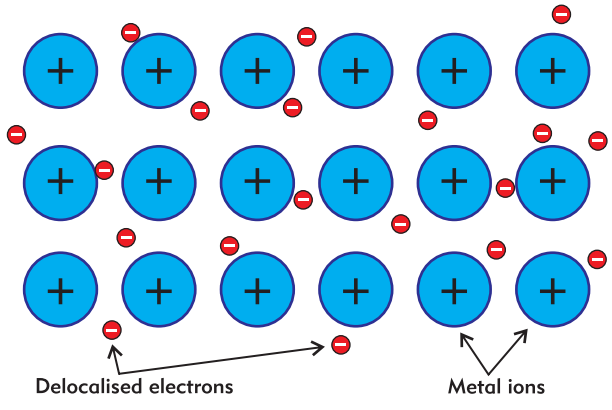


Fig 4.10 Diagramatic representation of metallic bonding

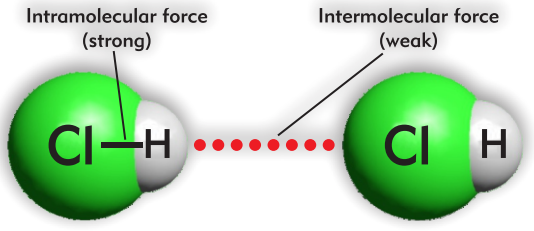
- Metal atoms loose the outer shell electrons and become positively charged ions and occupy a fixed position in a lattice.
- The outer shell electrons are free to move between the metal ions so are called delocalized electrons and move freely
- Thus the metal lattice structure shows positively charged ions surrounded by a delocalized outer electrons.

Test Yourself

- Magnesium is present in which group? How many electrons are in the outer shell of a magnesium atom?
- What is the charge of a magnesium ion and what is its symbol?
- Why Fluoride ion is not considered as Neon atom?
- Does anionic bond have a dipole?
- Describe the formation of anions for the following non-metals using dot cross structure.
  (a) Sulphur(atomic No.16) (b) Oxygen (atomic No.8)
- Where are valence electrons located, and why are they important?
- Why, noble gases do not react with other element to form compounds?
- Write the formation of cations for the following metals atoms using dot cross structure.
  (b) K (atomic No.19) (b) Al (atomic No.13)

4.4 INTERMOLECULAR FORCES

As we already discussed that some forces which hold the atoms together in a substance are called chemical bonds. Moreover, along with these strong bonding forces, weak forces are also created in between the molecules. These are called intermolecular forces. Thus, Intermolecular forces are defined as the set of all the forces that occur between two neighboring molecules. The bonding and intermolecular forces of hydrochloric acid are shown below:



These intermolecular forces are weaker than ionic and covalent bond. The interaction between intermolecular forces may be used to describe how molecules interact with each other. The strength or weakness of intermolecular forces determines the states of matter of a substance (e.g., solid, liquid, gas) and some of the physical properties (e.g., melting point, structure etc).

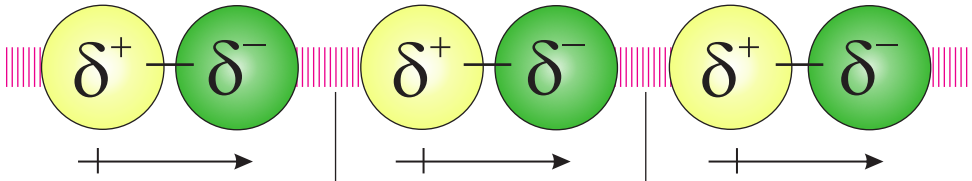
There are several types of intermolecular forces, but we will discuss two of them.

Do You Know?

Intra-molecular forces are forces between atoms within a single molecule. These forces are stronger than intermolecular forces as between H and Cl in HCl.

4.4.1 Dipole-Dipole Interaction

Dipole-Dipole interactions result when the two dipolar molecules interact with each other. When partially negative portion of one of the polar molecules is attracted to the partially positive portion of the second polar molecule, the electrostatic attraction is created between two molecules. These attractive forces are called Dipole-Dipole interactions and represented as below:



Dipole - Dipole Interactions

In the diagram, "δ" (read as "delta") means "slightly".

Example Dipole-Dipole Interaction

Dipole-dipole interaction can be seen in hydrogen chloride. Chlorine atoms are much more electro negative than hydrogen atoms. A partial negative charge is created on Chlorine and in turn a partial positive charge on hydrogen due to electronegativity difference.

$$\overset{\delta^+}{H}-\overset{\delta^-}{Cl}$$

When two molecules of hydrogen chloride come close to each other, the slightly negative end of one molecule is attracted to the slightly positive end of another molecule. These attractive forces are simply called dipole-dipole interaction as represented below:

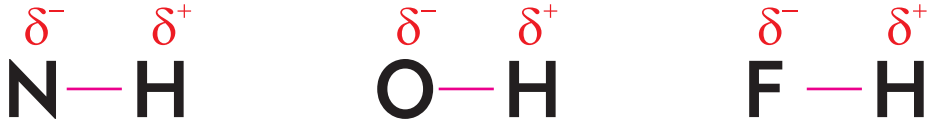
$$\overset{\delta^+}{H}-\overset{\delta^-}{Cl}\cdots\cdots\overset{\delta^+}{H}-\overset{\delta^-}{Cl}$$

4.4.2 Hydrogen Bonding

Hydrogen bond is a type of dipole dipole interaction. When hydrogen forms polar covalent with more electronegative atom like Nitrogen (N), Oxygen (O), Fluorine (F), Chlorine (Cl), Sulphur (S), then hydrogen gets partially positive charge and other electronegative atom get partially negative charge. The interaction between partially positive charged hydrogen atom of one molecule with electronegative atom of other molecule is called Hydrogen bonding.

In molecules containing N-H, O-H or F-H bonds, the large difference in electronegativity between the H atom and the N, O or F atom leads to a highly polar covalent bond.

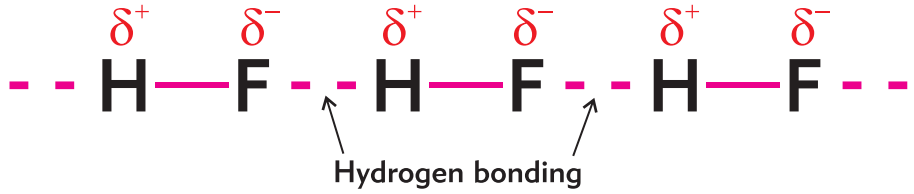
Because of the difference in electronegativity, the H atom bears a partial positive charge and the N, O or F atom bears a partial negative charge. (δ^+ and δ^- show slight charges).



The high partial positive charge on H atom enables to attract highly electronegative (N, O, or F) atom of the other molecule.

Example of Hydrogen Bonding

Consider the example of hydrogen fluoride. The fluorine atom is more electronegative. They tend to pull on the shared pair of electrons, creating a partial negative charge on itself and a partial positive charge on the hydrogen. The partial positive charge bearing hydrogen, then forms a bond with the electronegative atom of a neighboring molecule, while its electronegative element forms another bond with the positive hydrogen of another neighboring molecule. Therefore, several molecules combine by hydrogen bonding thus:



These intermolecular forces are extremely important in determining the properties of water, biological molecules, such as proteins, DNA etc. Synthetic material such as glue, paints and dyes are developed due to hydrogen bonding. Synthetic resins bind two surfaces together by hydrogen bonding or dipole-dipole interaction. Moreover, hydrogen bonding affects the physical properties of the molecules like melting and boiling point, density, solubility etc.

Test Yourself

- Why coordinate covalent bond is always a polar bond?
- Write down dot and cross structure of CCl_4
- Why does not a hydrogen atom form more than one covalent bond?
- Represent the formation of anions by the following nonmetals using electron 'dot' and 'cross' structure.
  (a) N (b) Br (c) P
- Why does a dipole occur in a molecule?

4.5 NATURE OF BONDING AND PROPERTIES

As discussed earlier the losing or gaining of electrons leads to ionic bonding, while the sharing of electrons leads to covalent bonding. The properties of the compounds depend upon the nature of bonds existing between them. Let us now discuss the effect of nature of bonding on the properties of compounds.

4.5.1 Ionic Compounds

Compounds having ionic bonds are called ionic compounds. The properties of ionic compounds relate to how strongly the positive and negative ions attract each other in an ionic bond. Most of the ionic compounds are in a solid or crystal form with strong electrostatic forces. Figure 4.11 shows the arrangement of Na^+ and Cl^- ions in NaCl. In crystal structure of sodium chloride each Na+ ion is surrounded by six Cl- ions. Similarly, each Cl- ions is surrounded by six Na+ ions.

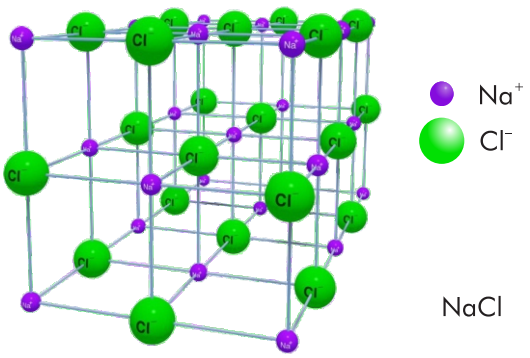


Figure 4.11 arrangement of ions in Solid crystal of NaCl

The ionic compounds exhibit the following properties:

i) Ionic compounds form crystals.

ii) Ionic compounds tend to be hard and brittle

iii) The large attracting forces result in a very stable structure. Therefore a lot of energy will be required to break these forces. So ionic compounds have high melting points. For example, melting point of NaCl is 801^{0}C and boiling point 1413^{0}C.

iv) Aqueous solutions of ionic compounds also conduct electricity. This is because when an ionic compound dissolves in water, the ions are free to move in aqueous solution.

v) Ionic compounds usually dissolve in polar solvent like water and are insoluble in non-polar solvents like oil, petrol, kerosene oil etc.

4.5.2 Covalent Compounds

As we know that covalent compounds are formed by mutual sharing of electrons between atoms. The bonding force of covalent bonds are generally weak as compared to ionic bond. The covalent compounds have following properties:

i) Covalent compounds usually exist as molecule i.e. H_2, O_2, H_2O but also can exist as crystals, examples include sugar crystals and diamond.
ii) The melting and boiling points of most covalent compounds are usually low.
iii) They are usually bad conductors of electricity.
iv) They are usually insoluble in water, but soluble in non-polar solvents like oil, petrol, kerosene, etc.

4.5.3 Polar and Non-polar Compounds

Polar and non polar both compounds differ in properties.

i) Nonpolar covalent compounds are generally insoluble in water while polar covalent compounds are soluble in water.
ii) Non-polar covalent compounds do not conduct electricity in the solid, molten or aqueous solution, but polar covalent compounds usually conduct electricity due to the formation of ions in water.
iii) Non-polar covalent compounds are soluble in non-polar solvent like petrol, benzene etc. While polar covalent compounds are insoluble in non-polar solvent.
iv) Few examples of polar covalent compounds are H_2SO_4, H_2O, HCl, HF, HBr, HI
v) Few examples of non-polar covalent compounds are CO_2, CH_4, C_2H_6.

4.5.4 Metal

Following are the different properties of metals such as:

- Metals are usually malleable and ductile.
- They are good conductor of electricity and heat due to the presence of delocalized electrons (mobile electrons).
- Melting and boiling points of metal are usually high as the atoms in metals are packed tightly.
- Metals have high densities.

Do You Know?

Malleable mean that metals can be hammered into different shapes and rolled into sheet.

Ductile is the property through which metal can be drawn into wires.

Test Yourself

- What do you understand about intermolecular forces between two molecules?
- Why metals are good conductor of electricity?

Society, Technology and Science

Uses of different synthetic adhesives like glue and epoxy resins

Synthetic adhesives like epoxy resins and glues are the substance that stick to the surface of the other objects. The material like plastic, wood, metal, ceramic glass and rubber etc at which glue is applied are called substrate. Epoxy adhesive is more expensive as compared to resin glue. Both are synthetic adhesives and require mixing before use, but epoxy hardens much faster than resin glue. We can use adhesive anytime to reattach the broken objects. For example, Poly vinyl acetate is a common white glue. It is used in book binding. Polyurethane glue is a flexible adhesive. It is used in fixing of soles to the bodies of shoes and wood working. Natural rubber bond to substrate on contact. It is used in self-adhesive envelopes. Conductive adhesive is commonly used in electronics to repair equipment. A mino resins are water soluble adhesive, they are used in bonding of layers in plywood. Epoxy glue contain epoxy. Its form strong bonds with glass, plastics, plywood, laminated boards and ceramic. Another use for epoxy resin is the decorative flooring applications. Commonly, epoxy resins are used where water resistance is required. Bridges, dams, power stations are also coated with epoxy resins.

Explain how Aircrafts, cars, trucks and boats parts are partially held together with epoxy adhesive (Analyzing)

The excellent adhesive properties of epoxy resins are due to the attractive forces between the epoxy resin and the surface of the substrate. One of the most common uses of epoxy resin is for adhesive purposes. For that purpose, epoxy resin is used in the construction of vehicles, trucks, boats and aircrafts. Its drying time is 6-30 minutes hardly.

Summary

- Every atom tries to achieve a noble gas configuration.
- Only outer most valence electrons are involved in bonding.
- Ionic bonding involves transfer of electrons.
- Metal reacts with non metal to form an ionic compound.
- Atoms which loose electron(s) form positive ions. Atoms which gain electron(s) form negative ion.
- In an ion, the number of electrons is different from the number of protons.
- Ionic bonding is commonly formed between elements of group IA or II A and groups VI A or VII A.
- Covalent bonding involves sharing of electrons and form molecules.
- The sharing of three pairs of electrons between two atoms is called a triple bond.
- Metal tends to lose valence electrons to form positively charged ions (cations).
- Non metals usually gain electrons to form negatively charged ions (anions)
- Common covalent molecules are water H_2O, Methane CH_4, Ammonia $NH_3$and carbon dioxide CO_2.
- A co-ordinate bond also called a dative covalent bond.
- A covalent bond can be polar or non-polar. But coordinate bond is only polar in which both electrons come from the same atom.
- The sharing of two pairs of electrons between two atoms is called a double covalent bond.
- A hydrogen bond is a partially electrostatic attraction between a hydrogen (H) which is bound to a more electronegative atom such as nitrogen (N), oxygen (O), or fluorine (F), and another adjacent atom bearing a lone pair of electrons
- When slightly negative end of polar molecule is weakly attracted to the slightly positive end of another molecule then such attracting forces are called dipole-dipole interactions.

EXERCISE

SECTION- A: MULTIPLE CHOICE QUESTIONS

Tick Mark (✓) the correct answer

1. An example of ionic compound is:

   (a) H_2 (b) CH_4 (c) N_2 (d) NaCl

2. Interaction between highly electron deficient hydrogen and highly electronegative atom is called

   (a) covalent bond (b) ionic bond

   (c) hydrogen bond (d) metallic bond

3. Two fluorine atoms share one electron each in their outermost shell to achieve electronic configuration of:

   (a) Xe (b) Ar

   (c) Kr (d) Ne

4. Number of electrons lost by atoms of group IIIA equals:

   (a) 1 (b) 2

   (c) 3 (d) 4

5. Atom which loses two electrons from its outer shell to form ion is:

   (a) oxygen (b) potassium

   (c) magnesium (d) carbon

6. In NaCl crystal lattice each Na^+ ion is surrounded by:

   (a) 6 Cl^- ions (b) 6 Na^+ ions

   (c) 8 Cl^- ions (d) 12 Cl^- ions

7. At room temperature most of ionic compounds are:

   (a) amorphous solids (b) crystalline solids

   (c) liquids (d) gases

8. Tendency of atoms to acquire eight electrons in their valence shell is:

   (a) octet rule (b) duplet rule

   (c) triplet rule (d) none of above

9. When one atom forms cation by losing electron and other forms anion by accepting that electron then bond form between them is:

   (a) Covalent bond (b) Ionic bond

   (c) coordinate covalent bond (d) hydrogen bond

10. Nobel gases are stable because they contain:
    (a) 4 electrons in valence shell (b) 6 electrons in valence shell
    (c) 8 electrons in valence shell (d) 10 electrons in valence shell
11. Bond which involve 3 shared electron pairs is a :
    (a) double covalent bond (b) single covalent bond
    (b) triple covalent bond (d) none of above
12. A non-metal atom form anion by
    (a) loses of electrons (b) gain of electrons
    (c) loses of protons (d) gain of protons
13. When two identical atoms share electron pairs and exert same force on each other than
    bond form is:
    (a) non-polar covalent bond (b) polar covalent bond
    (c) double covalent bond (d) coordinate covalent bond
14. Synthetic resins are used on places where:
    (a) electric resistance is required (b) water resistance is required
    (c) adhesion is required (d) friction is required
15. Oxygen belongs to group VIA so number of electrons in its valence shell are:
    (a) 4 (b) 2
    (c) 6 (d) 8
16. Electron pairs which are not shared by atoms are called:
    (a) electron pairs (b) lone pairs
    (c) bond pairs (d) shared pairs
17. Strength of intermolecular forces from ionic or covalent bond is:
    (a) Weaker (b) stronger
    (c) equal (d) none of above
18. Ionic crystals have:
    (a) high melting points (b) moderate melting points
    (c) low melting points (d) none of above
19. Bond formed by mutual sharing of electron is:
    (a) ionic bond (b) coordinate covalent bond
    (c) covalent bond (d) metallic bond

20. Which of the following diagram shows atoms are bonded with same electro negativity?

(a) A — B (b) A — B

(c) A — B (d) A — B

SECTION- B: SHORT QUESTIONS:

1. Draw dot and cross diagrams to show how different types of chemical bonds are formed when fluorine reacts with
   (a) Hydrogen (b) potassium
2. What is meant by octet and duplet rule?
3. Can you draw an ion which is formed by the atom losing three electrons?
4. How oxygen forms an anion?
5. What is the difference between lone pair and bond pair?
6. Explain why table salt has a very high melting point.
7. How is electronegative value determined the formation of chemical bond?
8. Why it is easy for magnesium atom to lose two electrons?
9. Atoms of metallic elements can form ionic bond, but they are not very good to form covalent bonds. Why?
10. How does an ion differ from an atom?
11. Describe dipole-dipole forces.
12. Write uses of adhesive material.
13. Why Intermolecular forces are weaker than intera molecular forces?
14. Write characteristics of metallic bond.
15. Ionic bonds are strong and hard to break but why most of the covalent compounds have low melting and boiling points.
16. Write down the characteristics of ionic compounds.
17. Why ionic compounds are solid?
18. How is hydrogen bonding affecting the physical properties of compounds?
19. Complete the chart:

Atomic Number	Number of protons	Number of electrons	Electronic configuration	Number of valence electrons
11	11	11	2, 8, 1	1
12				
13				
14				
15				
16				

SECTION- C: DETAILED QUESTIONS:

1. Define ionic bond. Discuss the formation of sodium chloride (NaCl).
2. Explain element attain stability?
3. Describe the formation of a covalent bond between two nonmetallic atoms. Explain single, double and triple covalent bond with examples.
4. How are electrons arranged in molecular compound? Draw electron dot and cross structures for the following atoms.
   (a) H_2O (b) N_2 (c) CH_4 (d) C_2H_2 (e) Cl_2 (f) H_2
5. Define metallic bond. How are metallic bonds are formed?
6. What is coordinate covalent bond? Explain with two examples.
7. What do you understand about ionic character of covalent bond?
8. Differentiate the properties of polar and non-polar covalent compounds.
9. Explain the importance of glues and epoxy resins in our society.