

Chemical Bonding

Chemical Bond:

A chemical bond is the force of attraction between atoms that leads to the formation of chemical compounds. The bond occurs because of,

- electrostatic force of attraction between atoms of opposite charges, and
- through the sharing of electrons (in covalent bonds).

Atoms lose, gain or share electrons to attain octet configuration and stability. The force of attraction is the result of the behaviour of outermost or valence electrons. Based on this force, different types of bonds are formed giving rise to different properties in compounds.

The strength of chemical bonds varies considerably leading to the formation of either strong or primary bonds and weak or secondary bonds.

- Strong bonds include ionic or electrovalent bonds, covalent bonds and co-ordinate covalent or dative bonds.
- Weak bonds include dipole-dipole interaction and hydrogen bonds.

The three main types of atomic bonds are:

1. **Ionic Bonds:** They are formed because of non-directional interatomic forces and electron transfer. They give structures of high coordination and there is electrical conductivity at low temperatures.
2. **Covalent Bonds:** They are formed because of localised (directional) large interatomic forces and electron sharing. They help form structures of low coordination and low conductivity at low temperature (for pure crystals).
3. **Metallic Bonds:** They are formed due to non-directional large interatomic forces.

Ionic or Electrovalent Bond:

Ionic bonding is the complete transfer of valence electron between atoms. Ionic bonds occur between metals (electron donors) and non-metals (electron acceptors) because of the electrostatic force of attraction between positive and negative ions.

Ionic or electrovalent bonds are formed under the conditions of low ionization energy, high electron affinity and high lattice energy.

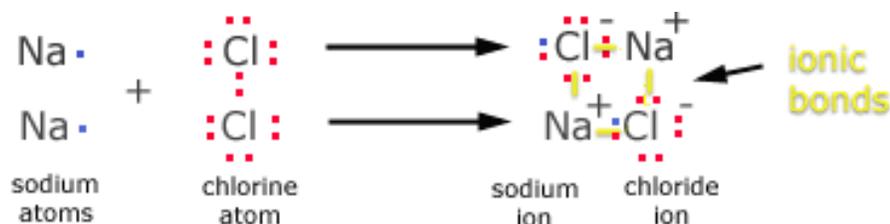
Why does ionic bonding occur?

- It occurs in metals because metals have few valence electrons and metals tend to lose electrons to attain octet configuration and achieve noble gas configuration.
- It occurs in non-metals since non-metals readily accept electrons to achieve noble gas configuration.

Characteristics of ionic bonds:

- Ionic compounds have high melting and boiling points.
- They are dense because their crystalline forms contain crystal lattices of tightly packed molecules.
- Their crystalline forms are always soluble in water.
- Crystals cannot conduct electricity in the solid state.
- The chemical bond generates two oppositely charged ions.
- Metals lose electrons to become a positively charged cations while non-metals accept those electrons to become a negatively charged anions.
- The charges on the anion and cation correspond to the number of electrons donated or received.
- The net charge of the compound is zero.

Formation of sodium chloride:



The electron lost by a sodium atom is gained by a chlorine atom to produce a sodium ion and a chloride ion.

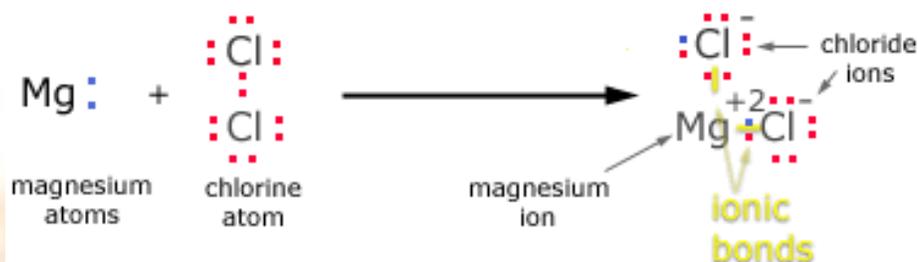
Formation of calcium oxide molecule:

Ca^{2+}	Calcium ion	O^{2-}	Oxide ion
20+	Protons	8+	Protons
18-	<u>Electrons</u>	10-	<u>Electrons</u>
2+		2-	

Once these two ions have been formed, they will attract each other because of their opposite charges.

There is an electrostatic attractive force present (like charges repel and unlike charges attract) that creates the chemical bond in the NaCl and CaO, called an ionic bond.

Formation of magnesium chloride:



The 2 electrons lost by a magnesium atom are gained by chlorine atoms to produce a magnesium ion and 2 chloride ions.

Covalent bond:

- Covalent bonds are formed between two or more atoms when they share electrons. They are normally formed between atoms of similar electronegativity and may occur between atoms of same or of different kind.
- Example: Hydrogen, oxygen, nitrogen share 1, 2 and 3 electrons respectively, with similar atoms to form molecules. Carbon and hydrogen share electrons to form hydrocarbons.
- Covalent bonds can be polar or non-polar. The more the difference in electronegativity, the more is the polar nature of the molecule.
- Polar covalent bonds are formed between atoms with difference in electronegativity, for example, water and hydrogen chloride.
- Covalent bonds are of three types: single covalent bonds, double covalent bonds and triple covalent bonds.

Conditions for the formation of a covalent bond:

- Both atoms should have four or more electrons in their outermost shells (non-metals with exceptions being H, Be, B, Al, etc.).
- Both the atoms should have high electronegativity, electron affinity and ionisation energy.
- The electronegativity difference between the combining atoms should be either zero or negligible.

Differences between Electrovalent and Covalent Compounds

Property	Electrovalent compounds	Covalent compounds
Nature	Hard solids, with strong electrostatic forces of attraction between constituent ions.	Gases, liquids or solids with weak forces of attraction between constituent atoms.
Boiling and melting points	High amount of energy needed to break strong bonding force between ions, hence they are considered non-volatile, with high boiling and melting points.	Less energy required to break weak forces of attraction between binding atoms, hence they are considered volatile with low boiling and melting points.
Ionization	Polar solvents decrease electrostatic force of attraction between constituent ions, so ions become available in aqueous solution.	They do not have ions, hence do not dissociate even in water

Dissociation	Ions dissociate in water or in molten state and migrate towards electrodes depending on charge present.	No dissociation of ions is found.
Solubility	Soluble in polar solvents. Example, chlorine, bromine.	Soluble in non-polar solvents. Example, toluene, benzene.

Co-ordinate Bond or Dative Bond:

- A coordinate covalent bond also known as a dative bond or coordinate bond is a type of covalent bond in which the two-shared electrons are supplied by the same atom.
- It is formed by two atoms sharing a pair of electrons where one of the atoms has a lone pair of electrons. The electrons are attracted to both the nuclei. The atom which supplies both the electrons is called donor and the other atom is called acceptor.
- A lone pair is a valence electron pair without bonding or sharing with other atoms. They are found in the outermost electron shell of an atom.
- Example:
 - Nitrogen has 5 valence electrons of which three are used for bonding with hydrogen to form ammonia.
 - Nitrogen in ammonia thus has one lone pair of electrons left.
 - When ammonia combines with a hydrogen ion it forms ammonium ion. Nitrogen is the donor and hydrogen is the acceptor.