Republic of Iraq
Ministry of Higher Education & Scientific research
Al-Mustaqbal University
Science College
Biochemistry Department

# Introduction in Chemistry

For

First Year Student/course 2

Lecture 9

By

Dr. Karrar M. Obaid

2024-2025

# Ionic Compounds

When an element with high electronegativity interacts with an element with low electronegativity, an attractive force forms between them, known as an ionic bond. The resulting compound is called an ionic compound.

Thus, an ionic compound is formed by the combination of a highly reactive metal (with low electronegativity) and a highly reactive nonmetal (with high electronegativity). The metal loses electrons, forming a positive ion, while the nonmetal gains electrons, forming a negative ion. Therefore, the formation of an ionic compound depends on the ionization energy of the metal and the electron affinity of the nonmetal. For this reason, two essential conditions must be met for the formation of an ionic compound:

1. One of the elements must have the ability to lose one or two electrons (and rarely three electrons) without requiring a very large amount of energy—meaning the element must have a low ionization energy.

2. The other element must have the ability to gain one or two electrons (and very rarely more) without needing a large amount of energy—meaning this element must have a high electron affinity.

Example of an ionic compound: Sodium chloride (NaCl)

For instance, chlorine has high electronegativity, while sodium has low electronegativity. An attractive force arises between them, forming an ionic bond, thus resulting in the compound sodium chloride.

Electron configurations:

- Na (Sodium): $1s^2\ 2s^2\ 2p^6\ 3s^1 \rightarrow Na^+$ (Sodium ion): $1s^2\ 2s^2\ 2p^6$
- Cl (Chlorine): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5 \rightarrow Cl^-$ (Chloride ion): $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

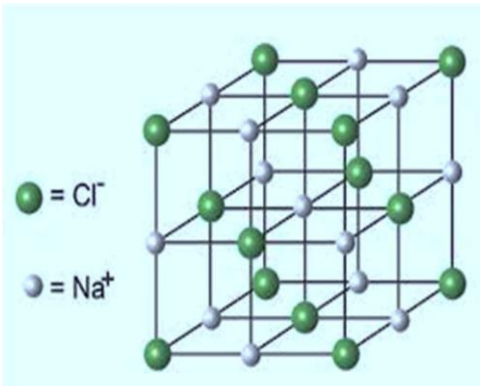
When examining the electron configurations above, we observe that:

- Sodium (Na) lost one electron, becoming the sodium ion ($Na^+$), which now has the same electron configuration as the noble gas neon [Ne].
- Meanwhile, chlorine, due to its high electronegativity, gained one electron and transformed into the chloride ion ($Cl^-$), acquiring the same electron configuration as the noble gas argon [Ar].

## Crystal lattice

The most important characteristic of ionic compounds is their structure, which is called a crystalline lattice, composed of positively and negatively charged ions packed tightly together. This arrangement maximizes the attractive forces between oppositely charged ions while minimizing repulsive forces between ions of the same charge. As a result, ionic compounds are solid and highly dense.

Ionic compounds are essentially assemblies of negative ions (anions) and positive ions (cations) arranged in a specific geometric pattern known as a crystal or crystal lattice.



# Properties of Ionic Compounds

The most important properties that distinguish ionic compounds from other types of compounds are:

1. **Poor electrical conductivity in the solid state, but good conductivity when molten. Why?**

The good electrical conductivity of molten ionic compounds is due to the presence of freely moving positive and negative ions that can migrate under an electric field. In the solid state, however, the ions are tightly bound in the crystal lattice, restricting their movement and making the solid non-conductive.

2. **Most ionic compounds have high melting and boiling points**. **Why**?

This is due to the strength of the ionic bonds, which require a large amount of energy to break.

3. **Most ionic compounds are very hard but brittle. Why?**

They are extremely hard because of the strong electrostatic attraction between positive and negative ions, making them difficult to separate. However, they are brittle because when an external force is applied, it can cause like-charged ions to repel each other, shifting their positions and causing the crystal to fracture.

4.Ionic compounds dissolve in polar solvents with a high dielectric constant.

The energy of attraction between two ions is given by the equation:

$E = (q^{+} q^{-}) / (\varepsilon r)$

Where:

E = Attraction energy between two ions

$q^+$, $q^-$ = Positive and negative ions

ε = Dielectric constant of the medium separating the ions

r = Distance between the ions

- From this equation, it is clear that the dielectric constant (ε) is inversely proportional to the attraction energy between the ions. A higher dielectric constant weakens the ionic attraction, facilitating dissolution in polar solvents.

Here are the dielectric constants (ε) of the mentioned substances in English:

- **Air = 1**

Ether = 15

Ammonia = 25

Acetonitrile = 33

Water = 78

**The dissolution of an ionic compound**

necessarily requires the breaking of the crystal lattice of the solute. The energy required to break the lattice comes from the energy released during the solvation process.

The reason polar solvents are effective in dissolving ionic compounds is their ability to dissolve them?

Because the dielectric constant of polar solvents is high, it leads to a reduction in the attractive forces between the ions.