Ionic, covalent chemical bonds and metallic bonds

The type of bond formed depends on the **electronegativity** of the element, that is, the attraction the element has for an electron, and the fact that the most stable arrangement of electrons around atoms has eight electrons, known as an octet.

The attraction which keeps atoms united within a molecule is called **chemical bond**. The atoms place themselves in the molecule so that the energy of the entity is minimal.

The different chemical bonds have different characteristics and properties. To simplify the study of chemical bonding we will consider three types of bonds**: ionic, covalent and metallic bonds**. Even though, it is sometimes difficult to classify a compound with a particular type of chemical bond as we can find compounds which present a covalent bond with a percentage of ionic bonding.

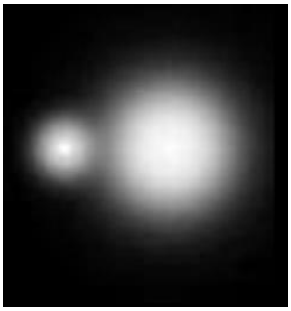
Ionic Bonds

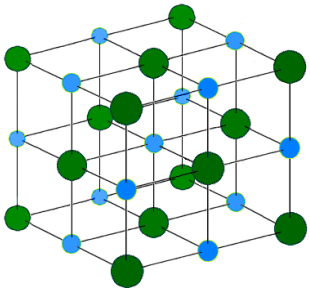
Ionic bonds form primarily between **metals and non-metals**. The electronegativity of metals is much smaller than that of non-metals. **Non-metals will remove valence electrons from metals**. This results in a **positively charged metal cation** and a **negatively charged non-metal anion**, both surrounded by an octet of electrons. The two oppositely charged ions attract each other and form a bond.

In ionic bonding we don't talk about molecules but minimal units. When these ions combine, they don't do it in couples. There are many atoms involved in this electron interchange, forming a crystal lattice.

Impression of two ions, for example Na^+ and Cl^-

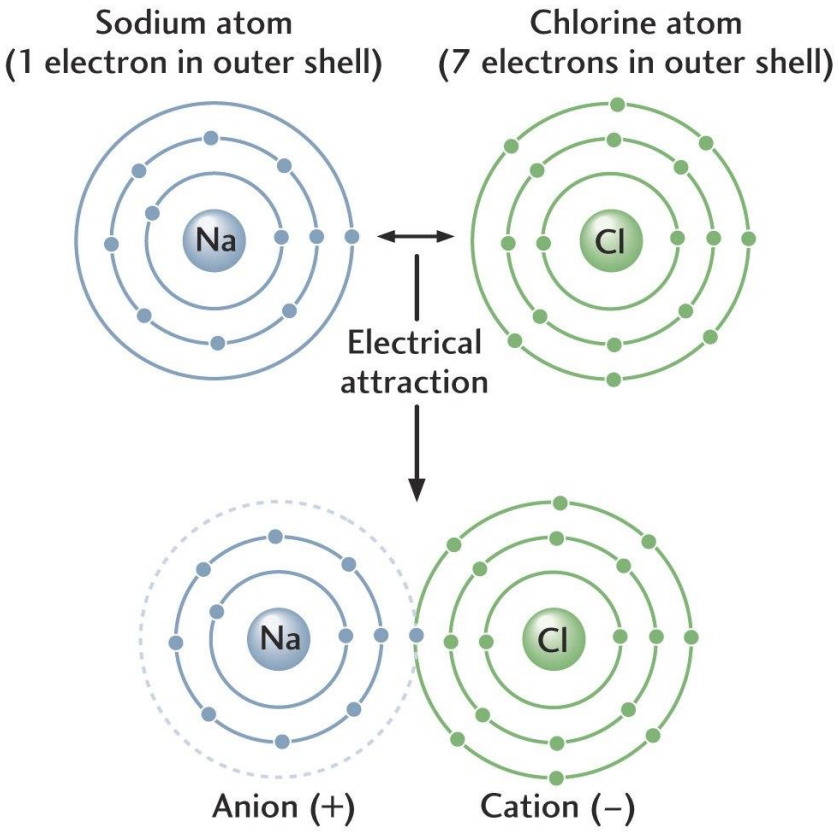
forming an ionic bond





Sodium chloride (halite) crystal structure. Each atom has six nearest neighbours (octahedral geometry). This arrangement is known as *cubic close packed* (ccp).

Light blue = Na^+ Dark green = Cl^-



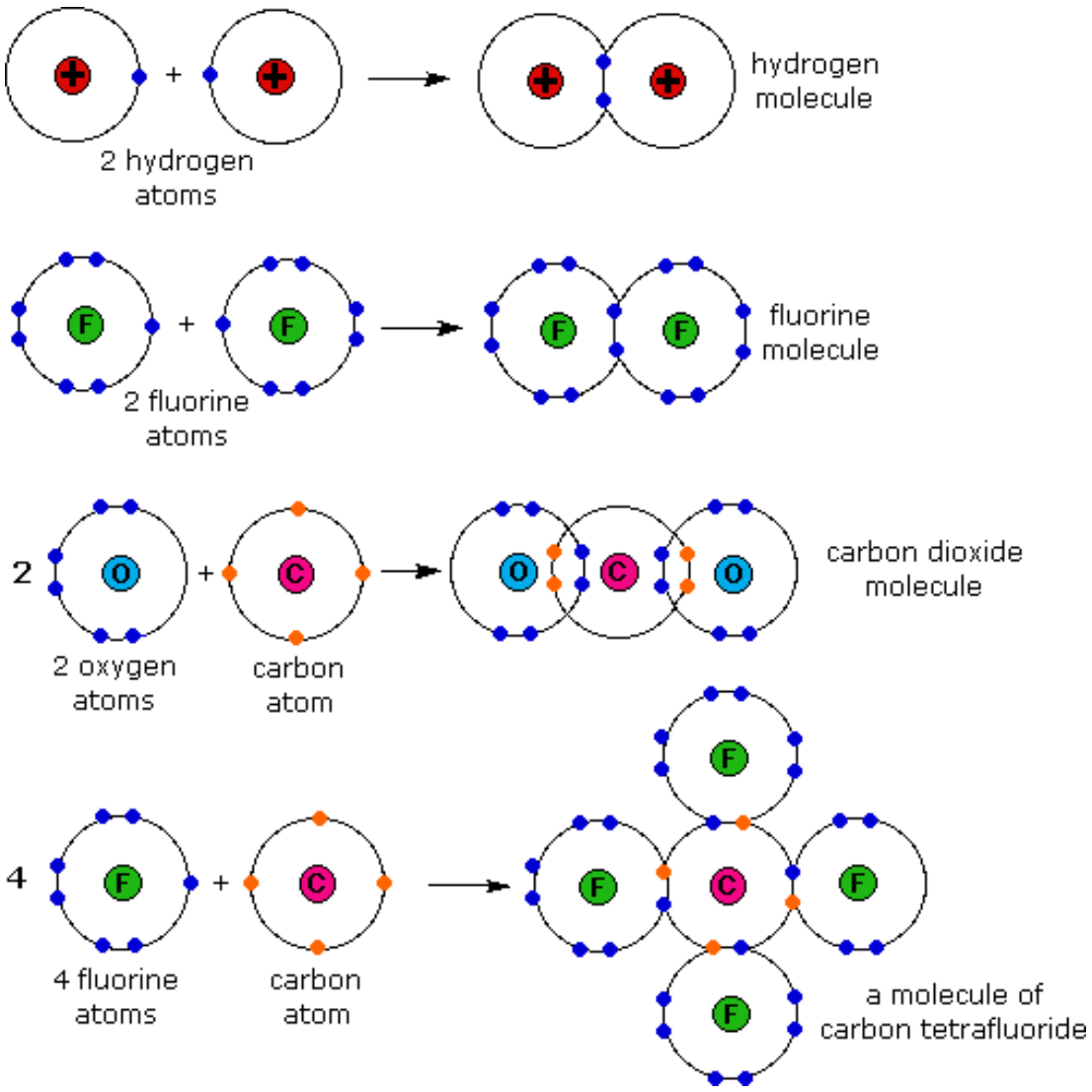
Properties of ionic compounds

1. Ionic compounds are crystalline solids at room temperature.
2. They are generally soluble in water.
3. They are non- conductors of electricity in their solid state. However, they are very good conductors of electricity when dissolved or molten. → **ionic conductivity.**
4. They present high fusion and boiling points due to strong interaction of its ions.

Covalent Bonds

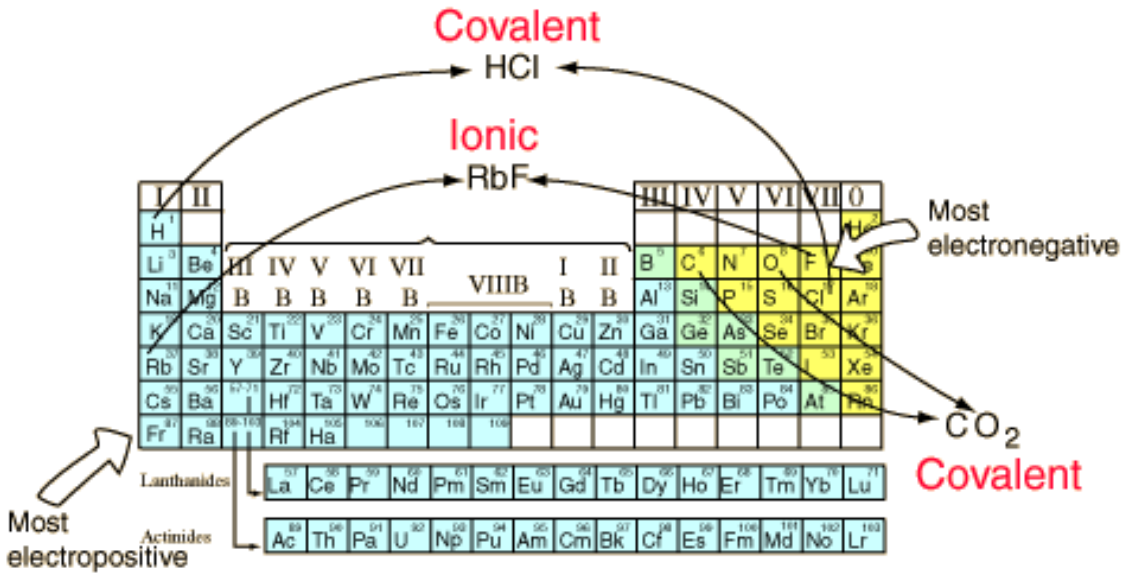
Covalent bonds are bonds where two atoms share valence electrons. Covalent bonds usually occur between non-metals that are either of the same element, or of elements close to each other on the Periodic Table. In covalent compounds the difference in electronegativity of its constituting atoms is small.

In covalent bonding electrons are shared in pairs. With few exceptions, covalent compounds form molecules.



Properties of molecular covalent compounds

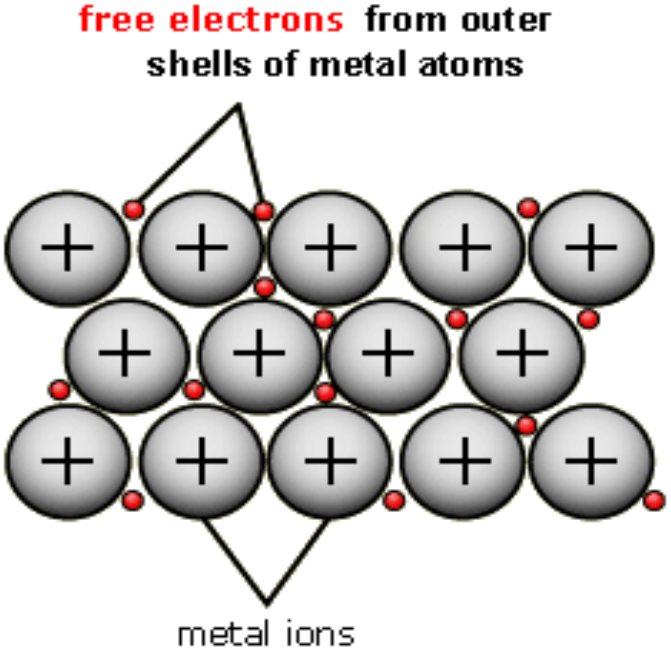
1. Most covalent compounds are gases or liquids at room temperature, and if they are solid they have a low melting point. They also have low boiling points.
2. They are poor conductors of heat and electricity, when solids.
3. They are softer than ionic compounds, although there are some hard covalent ones.
4. They are generally insoluble in water and might dissolve in organic solvents such us ethanol or cyclohexane.



Metallic bonds

Metallic bonding is the molecular bonding within metals.

Metallic atoms tend to lose their outer-shell electrons becoming positive ions or cations. The **electrons can move freely** within the orbitals, and so each electron becomes detached from its parent atom. **The electrons are said to be delocalised.** If we could take a look at the inside of a metal, we would see cations perfectly ordered and packed (forming a lattice). The free electrons form an electronic cloud moving among the cations avoiding their repulsion. The moving electrons are shared by all the cations. The bonding is often described as a sea of mobile electrons that surrounds a lattice of cations. The metal is held together by the strong forces of attraction between the positive nuclei and the delocalised electrons.



Properties of metals

1. Metals have a metallic lustre and high densities. With the exception of Li, Na and K, the rest are denser than water.
2. Metals are solid at room temperature, with the exceptions of mercury and gallium, which are liquid.
3. They are good conductors of heat and electricity.
4. Metals are malleable (can make thin sheets); and ductile (can be drawn out into thin wires).
5. They have high melting and boiling points (with the exception of Hg and Ga).
6. They have a tendency to unite with elements from the right hand side of the periodic table (non-metals). Except with the ones of the last column (the noble gases).

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