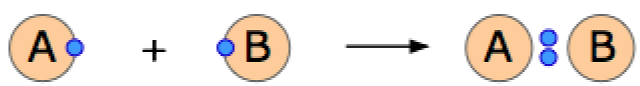
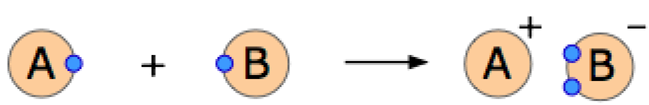
IONIC COMPOUNDS

The **shared-electron pair model** introduced by G.N. Lewis showed how chemical bonds could form in the absence of electrostatic attraction between oppositely-charged ions. As such, it has become the most popular and generally useful model of bonding in all substances other than metals. A chemical bond occurs when electrons are simultaneously attracted to two nuclei, thus acting to bind them together in an energetically-stable arrangement. The **covalent bond** is formed when two atoms are able to share a pair of electrons:



In general, however, different kinds of atoms exert different degrees of attraction on their electrons, so in most cases the sharing will not be equal. One can even imagine an extreme case in which the sharing is so unequal that the resulting "molecule" is simply a pair of ions:

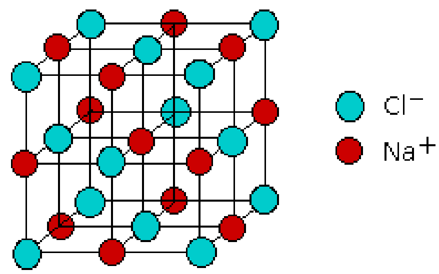


The resulting substance is sometimes said to contain an **ionic bond**. Indeed, the properties of a number of compounds can be adequately explained using the ionic model.

But does this mean that there are really two kinds of chemical bonds, ionic and covalent?

Bonding in ionic solids

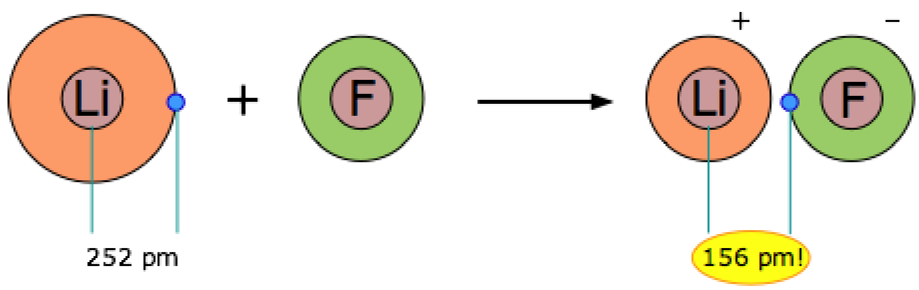
According to the ionic electrostatic model, solids such as NaCl consist of positive and negative ions arranged in a crystal lattice. Each ion is attracted to neighboring ions of opposite charge, and is repelled by ions of like charge; this combination of attractions and repulsions, acting in all directions, causes the ion to be tightly fixed in its own location in the crystal lattice.



Since electrostatic forces are nondirectional, the structure of an ionic solid is determined purely by geometry: two kinds of ions, each with its own radius, will fall into whatever repeating pattern will achieve the lowest possible potential energy. Surprisingly, there are only a small number of possible structures; one of the most common of these, the **simple cubic** lattice of NaCl, is shown here.

<u>Is there such as thing as an ionic bond?</u>

When two elements form an ionic compound, is an electron really lost by one atom and transferred to the other one? In order to deal with this question, consider the data on the ionic solid LiF. The average radius of the neutral Li atom is about 2.52Å. Now if this Li atom reacts with an atom of F to form LiF, what is the average distance between the Li nucleus and the electron it has "lost" to the fluorine atom? The answer is 1.56Å; the electron is now closer to the lithium nucleus than it was in neutral lithium!



So the answer to the above question is both yes and no: yes, the electron that was now in the 2s orbital of Li is now within the grasp of a fluorine 2p orbital, but no, the electron is now even closer to the Li nucleus than before, so how can it be "lost"? The one thing that is inarguably true about LiF is that there are more electrons closer to positive nuclei than there are in the separated Li and F atoms. But this is just the rule we stated at the beginning of this unit: **chemical bonds form when electrons can be simultaneously near two or more nuclei.**

It is obvious that the electron-pair bond brings about this situation, and this is the reason for the stability of the covalent bond. What is not so obvious (until you look at the numbers such as are quoted for LiF above) is that the “ionic” bond results in the same condition; even in the most highly ionic compounds, both electrons are close to both nuclei, and the resulting mutual attractions bind the nuclei together. This being the case, is there really any fundamental difference between the ionic and covalent bond?

The answer, according to modern chemical thinking is probably “no”; in fact, there is some question as to whether it is realistic to consider that these solids consist of “ions” in the usual sense. The preferred picture that seems to be emerging is one in which the electron orbitals of adjacent atom pairs are simply skewed so as to place more electron density around the “negative” element than around the “positive” one.

This being said, it must be reiterated that the ionic model of bonding is a useful one for many purposes, and there is nothing wrong with using the term “ionic bond” to describe the interactions between the atoms in the very small class of “ionic solids” such as LiF and NaCl.

Source: http://www.chem1.com/acad/webtext/chembond/cb04.html