8.1: What is a Chemical Bond?

Learning Objectives

- To present three common features of chemical bonding

A **chemical bond** is the force that holds atoms together in a chemical compound. There are three idealized types of bonding: covalent bondingA type of chemical bonding in which electrons are shared between atoms in a molecule or polyatomic ion., in which electrons are shared between atoms in a molecule or polyatomic ion, ionic bondingA type of chemical bonding in which positively and negatively charged ions are held together by electrostatic forces., in which positively and negatively charged ions are held together by electrostatic forces and **metallic bonding**, where all of the atoms in the metal share a few of their electrons which are free to circulate. One can relate the properties of materials to the type of bonding. Ionic compounds, for example, typically dissolve in water to form aqueous solutions that conduct electricity as the ions separate into solution. Solid ionic compounds do not conduct eletricity or heat. In contrast, most covalent compounds that dissolve in water form solutions that do not conduct electricity because they go into the solvent as neutral molecules. The solids or liquids are not conductors. In metals, of course, the free electrons conduct electricity, and what is not obvious, also heat. Metals are good conductors of both. Further, in general, covalent compounds are volatile because the forces holding the neutral molecules together are relatively weak, whereas ionic compounds are not because the individual ions are strongly attracted to each other.

Despite the differences in the distribution of electrons between these idealized types of bonding, all models of chemical bonding have three features in common:

1. Atoms interact with one another to form aggregates such as molecules, compounds, and crystals because doing so lowers the total energy of the system; that is, the aggregates are more stable than the isolated atoms.
2. The type of bonding is determined by how the outermost electrons of an atom, the so called **valence** electrons of one atom interact with neighboring atoms. In ionic materials electrons are fully transferred. Covalent materials share electrons with neighboring atoms and metals share electrons over a wide region.
3. Energy is required to dissociate bonded atoms or ions into isolated atoms or ions. For ionic solids, in which the ions form a three-dimensional array called a *lattice*, this energy is called the lattice energyThe enthalpy change that occurs when a solid ionic compound (whose ions form a three-dimensional array called a lattice) is transformed into gaseous ions., the change that occurs when a solid ionic compound is transformed into gaseous ions. For covalent compounds, this energy is called the bond energyThe enthalpy change that occurs when a given bond in a gaseous molecule is broken., which is the change that occurs when a given bond in a gaseous molecule is broken. The details of these processes will be discussed at the end of this semester when we study thermochemistry.
4. Each chemical bond is characterized by a particular optimal internuclear distance called the bond distance(r_0)The optimal internuclear distance between two bonded atoms..

Note the Pattern

Energy is required to dissociate bonded atoms or ions.

We explore these characteristics further, after briefly describing the energetic factors involved in the formation of an ionic bond.

Summary

Chemical bonding is the general term used to describe the forces that hold atoms together in molecules and ions. Three idealized types of bonding are **ionic bonding**, in which positively and negatively charged ions are held together by electrostatic forces, **covalent bonding**, in which electron pairs are shared between atoms and metallic bonding where electrons are shared across large volumes of metal atoms ionic cores. All models of chemical bonding have three common features: atoms form bonds because the products are more stable than the isolated atoms; bonding interactions are characterized by a particular energy (the **bond energy** or **lattice energy**), which is the amount of energy required to dissociate the substance into its components; and bonding interactions have an optimal internuclear distance, the **bond distance**.

Key Takeaway

- Forming bonds lowers the total energy of the system, energy is required to dissociate bonded atoms or ions, and there is an optimal bond distance.

Conceptual Problems

1. Describe the differences between covalent bonding and ionic bonding. Which best describes the bonding in $MgCl_2$ and PF_5?
2. What three features do all chemical bonds have in common?

Contributors

- Anonymous

Modified by Joshua Halpern