Chapter 3: Elements of Chemistry

Detailed Chapter Summary

A *physical property* describes the physical attributes of a material, such as its mass, color, or phase. During a *physical change* there is no change in how the atoms of molecules are connected together. An example is the evaporation of water. A *chemical property* is the tendency of a material to change into a different material. For example, it is a chemical property of wood to burn producing carbon dioxide and water vapor. During a *chemical change*, atoms change partners and by doing so create an entirely new substance. An example is the conversion of water into its elemental components: molecular hydrogen, H_2, and oxygen, O_2. A chemical change is synonymous with a *chemical reaction*. During a chemical reaction (chemical change) atoms change how they are bonded to one another.

As a material undergoes some sort of change it can be difficult to assess whether that change is physical or chemical. The reason for this is that both physical and chemical changes result in a change in appearance. In general, physical changes can be reversed by restoring the material to previous conditions. Most chemical changes we encounter are not so readily reversible. Furthermore, gram for gram, chemical changes typically involve the release of more energy than do physical changes.

You should understand that an *element* is a material made of only a single kind of atom, whereas a *compound* is a material made of more than one kind of atom. We use the terms element and compound when referring to macroscopic samples. The fundamental component of an element is the "atom," and a fundamental component of a compound is the "molecule." But you shouldn't be thrown off balance when your instructor tells you that an element can also be made of molecules. Got that?

Note that the periodic table need not be memorized. Rather, it is more important that you learn how the periodic table is organized such that the properties of an element can be deduced based upon its relative position within the periodic table. Atoms to the lower left, for example, tend to be larger than atoms to the upper right. Based upon this "periodic trend," you can predict the relative size of two atoms. Platinum, Pt, is closer to the lower left of the table than is Zinc, Zn. Because of this, you can predict that a platinum atom is larger. No memorization of atomic sizes is necessary. Chemists learn how to use the periodic table much like a writer learns how to use a dictionary. Neither need be memorized.

That said, you should be familiar with how the elements are organized within horizontal rows, called *periods*, and vertical columns, called *groups*. The properties of elements within a single period gradually change from left to right across the periodic table. The properties of elements within the same group are very similar. For example, all the elements of group 18 are inert gases.

When atoms of different elements bond to one another, they make a *compound*. A compound is represented by the chemical formula, which uses subscripts to indicate the ratio of atoms within the compound. The chemical formula for water, for example, is H_2O and that of hydrogen peroxide is H_2O_2. Note: water and hydrogen peroxide are both made of the elements hydrogen and oxygen. Yet these are two very different materials because they have different proportions of these elements.

Chapter 3 touches upon how we name compounds. The name of the element farther to the left in the periodic table is followed by the name of the element farther to the right, with the suffix "-ide" added to the name of the latter. Consider the compound sodium chloride and note that sodium is on the left side of the periodic table. Sometimes a suffix is used to distinguish compounds with different proportions of the same element. The technical names for water and hydrogen peroxide, for example, are dihydrogen monoxide and dihydrogen dioxide, respectively. Lastly, there are groups of atoms commonly encountered known as *polyatomic ions*.

A *mixture* is a combination of two or more substance in which each substance retains is properties. The components of a mixture can be isolated by taking advantage of the differences in their physical properties. For example, water can be removed from a mixture of saltwater by boiling the saltwater. The water, which has a much lower boiling point, evaporates, but the salt remains behind.

Chemists classify a material as either *pure* or *impure*. If it is pure, then it consists of only one element or compound. If it is impure, then it is a mixture. Of course, atoms and molecules are so small that it is impractical to have a material that is 100% pure. Mixtures can be classified as *heterogeneous* or *homogeneous*. In a heterogeneous mixture, the different components can be visually distinguished—think sand and salt. Homogeneous mixtures are mixed finely down to the level of molecules—think of the air we breath or of blood. Homogenous solutions can be classified further as *solutions* (air) or *suspensions* (blood) depending upon whether the components are within the same phase.

This chapter concludes with a discussion of *nanotechnology*, which is technology that works on the scale of the nanometer—the realm of atoms and molecules. Like microtechnology ushered in the revolution of computers, nanotechnology offers significant advances in computers as well as many other fields, including medicine.