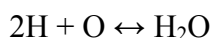


ESRM 210 Background Chemistry

Atoms and Molecules

The basic unit of chemical elements is the atom. In terms of chemical reactions, atoms are made up of protons (one positive charge), neutrons (no charge) and electrons (one negative charge). Protons and neutrons are the “core” of an atom, and electrons rotate around this nucleus. Atoms combine through chemical reactions to form larger units called molecules. Let's consider the reaction where hydrogen and oxygen combine to form water:



Reaction 1.

In this example, 2 Hydrogen atoms have combined with 1 Oxygen to form 1 Water molecule through a chemical reaction. Note that the double arrow means that the reaction is reversible, and under the right circumstances will proceed either to the left or to the right. Also note that the atoms in this reaction combine in specific proportions.

Atomic Weights and Moles

Each atom of an element weighs a specific amount depending on the number of neutrons and protons it contains (electrons are so small and light they contribute almost nothing to weight). Atomic weight is the weight of an atom of an element. For example, hydrogen has an atomic weight of 1 and oxygen has an atomic weight of 16. The term “moles” is used to describe a specific number of atoms (much like calling 12 a dozen a mole is 6.02×10^{23} atoms). So, if you have one mole of hydrogen and one mole of oxygen, you have exactly the same number of atoms of each element, but 16 times more oxygen by weight. In reaction 1, we combined 2 moles of hydrogen with 1 mole of oxygen; you would need to have 2 grams of hydrogen and 16grams of oxygen for a complete reaction which would yield 18 grams of water (1 mole).

Chemical reactions are like recipes; that is, you can divide the portions of hydrogen and oxygen in half and produce half as much water (1/2 moles of water), or you can double the portions to produce twice as much water (2 moles of water), or any other combination. The reaction of hydrogen and oxygen to water will be complete as long as we add twice as many moles of hydrogen to oxygen. When you read a chemical reaction, the number in front of an element always indicates the number of moles of that element or molecule.

Ions and Valence States

Atoms can gain, lose or share electrons. If an atom gains or loses an electron (remember electrons have a negative charge) it will become charged. Charged atoms are called ions.

The valence of an ion is equal to the number of electrons lost or gained and is indicated by a plus sign for cations (a positively charged ion) or a minus sign for anions (negatively charged ion). Because of the configuration of the electrons rotating around the nucleus of an atom, some atoms readily gain or lose electrons to become more stable. When salt (sodium chloride) is added to water, the following dissociation reaction occurs:



Sodium (Na^+) gives up an electron to chlorine to form chloride (Cl^-). A superscript is used to indicate charge (for example, Fe^{+3} indicates an iron ion with a valence state of +3).

Chemical Bonds

Chemical bonds create molecules. Chemical bonds are formed by transfers or sharing of electrons. In reaction 1, hydrogen (which only has one electron and readily loses or shares it) donates an electron to oxygen. Because oxygen is most stable when it acquires two electrons, two hydrogens combine with one oxygen. However, these electrons are not completely captured by the oxygen, and are actually shared with the hydrogen atom. When atoms in a molecule are shared, the bonds holding the atoms together are called covalent bonds. Covalent bonds occur between some atoms to increase their stability. Atmospheric oxygen (a molecule) is formed by the covalent bond of 2 oxygen atoms which share their electrons.



The oxygen molecule is uncharged because no electrons were gained or lost. The molecule is more stable than the individual atoms. Covalent bonds are very common in organic compounds. Ionic bonds are formed when an electron is virtually completely transferred from one atom to another (as in Reaction 2).