Types of Chemical Reactions

There are four important types of chemical reactions: acid–base reactions, precipitation reactions, complexation reactions, and oxidation–reduction reactions. Here is a brief guide that will help you recognize these reactions.

Acid–Base Reactions. In an acid–base reaction, a proton, H^+, moves from one species, which we call the acid, to another species, which we call a base. A key element of these reactions is the presence of two reactant and two products that differ only in the number of protons. For example, when if you mix together acetic acid, CH_3COOH, and ammonia, NH_3, the reaction is

$$CH_3COOH(aq) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + CH_3COO^-(aq)$$

Note that the difference between CH_3COOH and CH_3COO^- is a single proton, and that the difference between NH_3 and NH_4^+ also is a single proton. The species H_3O^+ and OH^- usually indicate an acid–base reaction, but be sure that they are paired with H_2O on the opposite side of the reaction as OH^- by itself also serves as a ligand in some complexation reactions (see below for a discussion of complexation reactions).

Precipitation Reactions. These are easy to identify as they always result in the formation of a solid as one or more of the reaction's products.

Complexation Reactions. In the most common type of complexation reaction, a metal ion and a ligand combine to form a soluble ion. The complex forms because the ligand donates a pair of electrons to form a bond with the metal ion. Many ligands are anions, but some ligands are neutral molecules that have a pair of electrons that they can donate to form a bond. Good examples of neutral ligands from the last experiment are H_2O and NH_3; the light blue color of Cu^{2+} was due to the presence of $Cu(H_2O)_6^{2+}$, and the dark blue color when you add NH_3 to Cu^{2+} was due to the presence of $Cu(NH_3)_4^{2+}$.

Oxidation–Reduction Reactions. In an oxidation–reduction reaction, electrons move from one species to another species. This often is the hardest type of reaction to recognize because you must look for changes in oxidation states. We will examine this in more detail later in the semester, but for now, look for situations where an element appears on one side of the reaction in its native element state—such as $H_2(g)$ or $Cu(s)$—and in another form on the other side of the reaction. For example

$$Cu(s) + 4HNO_3(aq) \rightleftharpoons 2NO_2(g) + Cu(NO_3)_2(aq) + 2H_2O(l)$$

is an example of an oxidation–reduction reaction because elemental copper, $Cu(s)$, appears as a reactant and copper(II), Cu^{2+}, appears as a product, shown here as $Cu(NO_3)_2(aq)$. In this case, the other species changing oxidation states is nitrogen; how to tell this is something we will return to later in the semester.