3.5: Polyatomic Ions

The compound NaOH has wide industrial use and is the active ingredient in drain cleaners. Based on the discussion in the previous section, we would expect NaOH to be an ionic compound because it contains sodium, a Group 1A metal. Hydrogen and oxygen, however, are nonmetals, and we would expect these to bond together covalently. This compound, called sodium hydroxide, is an example of an ionic compound formed between a metal ion (sodium) and a *polyatomic ion* (HO^-). Charged groups of atoms, like HO^-, that are bonded together covalently are called **polyatomic ions**. Within an ionic compound a polyatomic behaves as a single unit forming salts with other cations or anions.

Using the rules described in Section 3.2, we can draw a Lewis diagram for HO^-. Oxygen has six valence electrons and hydrogen has one, for a total of seven. The central atom in our structure will be hydrogen (it is to the *left* of oxygen in the periodic table). Next, because this is a polyatomic ion with a single negative charge, we add the extra electron to the central atom, pair the electrons and then draw the two atoms bonded together. Next, the six remaining electrons are distributed around the oxygen to form an octet. Finally, the polyatomic ion is enclosed in brackets with the charge as a superscript to show that the ion behaves as a single unit.

Polyatomic ions are very common in chemistry. It is *essential* that you memorize these and be able to correlate the name, the composition and the charge for each of them, as they will be discussed freely throughout the remainder of the course and you will be expected to know these in General Chemistry.

✔ Example 3.5.1:

Construct a Lewis diagram for the polyatomic ion CO_3^{2-}.

Solution

Oxygen has six valence electrons and carbon has four; therefore in CO_3^{2-} there will be a total of 22 valence electrons, plus two additional electrons from the 2- charge. The central atom in our structure will be carbon (it is to the *left* of oxygen in the periodic table). Next, we draw the carbon (our central atom) with its' four electrons and add the additional two electrons from the charge. The three oxygens are placed around the carbon and the electrons are arranged to form the three covalent bonds. Next, the 18 remaining electrons are distributed around the oxygens so that they all have a full octet. The carbon, however, is only surrounded by six electrons. To remedy this, we move one electron pair in to form a double bond to one of the oxygen atoms. Finally, the polyatomic ion is enclosed in brackets with the charge as a superscript.

We need to understand that the process of placing electrons into a particular bond in a compound is an *artificial* aspect of building Lewis diagrams. In fact, the electrons are added to the polyatomic ion, but it is *impossible* to know exactly where they went.

? Exercise 3.5.1

a. Draw Lewis diagrams for NO_2^- and NH_4^+.