3.4: Lithium, The First Metal

The element with atomic number 3 is lithium (Li), atomic mass 6.941. The most abundant lithium isotope is $^{7}_{3}\mathrm{Li}$ having 4 neutrons in its nucleus. A few percent of helium atoms are the $^{6}_{3}\mathrm{Li}$ isotope, which has only 3 neutrons. The third electron in lithium cannot fit in the lowest energy shell, which, as noted above, is full with only 2 electrons. Therefore, the third electron in lithium goes into a second shell, that is, an **outer shell**.

As a consequence of its electronic structure, lithium is the lowest atomic number element that is a **metal**. In a general sense, metals are elements that normally have only 1–3 electrons in their outer shells. These electrons can be lost from metals to produce positively charged *cations* with charges of +1, +2, or +3. In the pure elemental state metals often have a characteristic **luster** (shine), they are **malleable** (can be flattened or pushed into various shapes without breaking) and they **conduct electricity**. Although some metals, notably lead and mercury, are very dense, lithium is the least dense metal at only 0.531 g/cm3.

Two of lithium's 3 electrons are **inner electrons** contained in an **inner shell** as in the immediately preceding noble gas helium. Inner shell electrons such as these stay on average relatively close to the nucleus, are very tightly held, and are not exchanged or shared in chemical bonds. As mentioned above, the third electron in lithium is an **outer electron** farther from, and less strongly attracted to, the nucleus. The outer electron is said to be in the atom's *outer shell*. These concepts are illustrated in Figure 3.4.

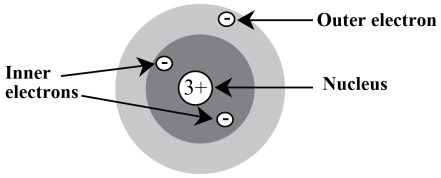

Figure 3.4. An atom of lithium, Li, has 2 inner electrons and 1 outer electron. The latter can be lost to another atom to produce the Li^+ ion, which is present in ionic compounds (see Section 2.12).

The Lewis symbol for atoms such as lithium that have both inner shell and outer shell electrons normally shows just the latter. (Inner shell electrons can be shown on symbols to illustrate a point, but normally this takes too much space and can be confusing.) Since lithium has only one outer shell electron, its Lewis symbol is

$$\mathbf{Li\cdot}$$

Consider that the lithium atom has an inner shell of 2 electrons, just like helium. Being only 1 electron away from the helium noble gas structure, lithium has a tendency to lose its extra electron so it can be like helium as shown by the following:

$$\mathbf{(Li:)\cdot \rightarrow Li:^{+} + e^{-}} \quad (3.4.1)$$

Note that the product of this reaction is no longer a neutral atom, but is a positively charged Li^+ *cation*. In losing an electron to become a cation, the lithium atom is said to be **oxidized**. When lithium forms chemical compounds with other elements, it does so by losing an electron from each lithium atom to become Li^+ cations. These, then, are attracted to negatively charged *anions* in ionic compounds.

Lithium compounds have a variety of uses. Lithium carbonate, Li2CO3, is widely prescribed as a pharmaceutical to alleviate the symptoms of mania in manic-depressive and schizo-affective mental disorders. Lithium carbonate is the most common starting material for the preparation of other lithium compounds and is an ingredient of specialty glasses and enamels and of ceramic ware that expands only minimally when heated. Lithium hydroxide, LiOH, is used to formulate some kinds of lubricant greases. In combination with iodine, lithium has been used to make cells that are sources of electricity for cardiac pacemakers. Implanted in the patient's chest, some of these pacemakers and their batteries have lasted for 10 years before having to be replaced.

Long an element with limited uses, lithium has become a rather "exciting" metal in the newly emerging sustainability economy because lithium-based storage batteries in which Li^+ ion is a charge carrier have become the storage batteries of choice for computers, portable electric devices and, especially, electric and hybrid automobiles. Lithium storage batteries exhibit superior qualities with respect to charge held per unit mass, stability, and longevity. In addition, lithium dry cells in which Li metal is irreversibly converted to Li^+ ion during discharge have become attractive (though expensive) options in the throwaway dry cell market because they are very long lived and carry much more charge per unit mass than standard alkaline dry cells.

The most common source of lithium is lithium brines where lithium has become concentrated by leaching of rock and evaporation of water from highland salt flats in South America and western China. Lithium salts are collected for processing from the evaporation of water from the brines in evaporation ponds. Bolivia is the largest producer of lithium and there is significant potential of production from Chile, Argentina, Australia, China, and perhaps even the state of Nevada. As use of lithium in batteries increases, recycled lithium from spent batteries will become an important source of the element.
