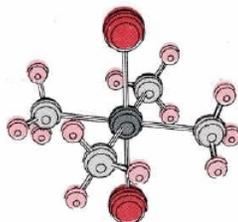


22.1: Prelude to Metals

Approximately three-quarters of the known elements display the macroscopic properties characteristic of metals. They conduct both heat and electricity very well; they have shiny surfaces; they are capable of being shaped by hammering (malleable) and also of being drawn into wires (ductile). These properties can be understood in terms of [metallic bonding](#) in which valence electrons are delocalized over an entire metallic crystal. Positive metal ions formed by loss of valence electrons are held together by an electron sea. The strength of metallic bonding varies roughly as the number of electrons available in this sea. Chemical properties of the metals include a tendency to lose electrons and form positive ions, and the ability of their oxides to function as bases. The extent of these characteristics varies from one metal to another. Several borderline cases such as B, Si, Ge, As, Sb, and Te are difficult to classify as metals or nonmetals. These elements are usually referred to as the **metalloids** or **semimetals**. As you will recall from the discussion of metals on the periodic table, one can draw a zigzag line across the periodic table from B to At which separates the metals from the nonmetals and semimetals. This line is clearly indicated in most periodic tables. Periodic Table Live allows you to select metals, semi-metals, or non-metals and see how they are divided on the periodic table.

A great many metals and alloys are of commercial importance, but metals occur naturally in oxide, carbonate, or sulfide ores. Such ores must be concentrated (beneficiated) before they can be reduced to the metal, and usually the raw metal must be purified (refined) in a third step. An excellent example of these processes involves iron which can be readily beneficiated because its ore is ferromagnetic. Iron ore is then reduced in a blast furnace and purified in a steel making furnace. Since ore-reduction is a nonspontaneous process, its reverse, oxidation or corrosion of a metal, is often a problem. This is especially true in the case of iron because the oxide coating which forms on the metal surface does not protect the remaining metal from atmospheric oxidation.



Here we will be concerned mainly with the transition metals. We have already covered metals which are [representative elements](#), such as [alkali metals](#) and [alkaline earth metals](#). A discussion of the lanthanoid and actinoid metals is beyond the scope of general chemistry. Since transition metals contain *d* electrons in their valence shell, their chemistry is somewhat different from that of the representative elements. In particular they form a family of compounds called complex compounds or coordination compounds which are very different from those we have encountered up to this point. In these complexes, several ligands which can serve as Lewis bases are bonded to a metal ion which serves as a Lewis acid. The number of ligands is called the coordination number, and defines the possible geometries of a complex. For a coordination number of 2 the complex is usually linear. Both square planar and tetrahedral structures occur for coordination number 4, and coordination, number 6 usually involves an octahedral structure. Square planar and octahedral structures give rise to cis-trans isomerism.

Some ligands, called [chelating agents](#), can coordinate-covalent bond to metal ions at more than one site. Chelate complexes are often important in biological systems because they can disguise the charge of a metal ion, stabilizing the ion in a hydrophobic environment.

In aqueous solution transition-metal ions are usually octahedrally coordinated by water molecules, but often other ligands which are stronger Lewis bases replace water. Such reactions often produce color changes, and they are usually rapid. A few metal ions, such as Cr(III), Co(III), Pt(IV), and Pt(II), undergo ligand substitution rather slowly and are said to be inert. Metal ions whose reactions are rapid are said to be labile.

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