

## Chapter 11

**Section 11.1** Students should know that most metals are malleable and ductile and that the conductivity of metals can be explained by **band theory** which describes the easy movement of electrons from the **valence band** to the **conduction band**.

**Section 11.2** Students should know that semimetals (metalloids) are **semiconductors**, intermediate in conducting ability between metals and nonmetals. The energies of the conduction band and the valence band are separated by a **band gap**. You should know that substituting electron-rich atoms into a semiconductor (such as group 15 elements into silicon) results in **n-type** semiconductors and that substituting electron-poor atoms (such as group 13 elements into silicon) results in **p-type** semiconductors. Both types of substitution increase the conductivity of the semiconductor by decreasing its band gap.

**Section 11.3** Students should know that many metallic crystals are based on **cubic closest-packed (ccp)** and **hexagonal closest-packed (hcp)** atoms, which are the two most efficient ways of packing atoms in a solid. It is critical that you understand that **crystalline solids** contain repeating units called **unit cells**. They include **simple cubic**, **body-centered cubic (bcc)**, and **face-centered cubic (fcc) unit cells**. It is very important that you understand that the crystal structure of a metal can be used to determine the radius of its atoms and predict its density (know how to do these things).

**Section 11.4** Students should know that **alloys** are blends of a host metal and one or more other elements (which may or may not be metals) that are added to enhance the properties of the host including strength, hardness, and corrosion resistance. In substitutional alloys atoms of the added elements replace atoms of the host metal in its crystal structure. In interstitial alloys atoms of added elements are located in the tetrahedral and/or octahedral holes between atoms of the host metal.

**Section 11.5** Students should know that aluminum and aluminum alloys are highly desirable for applications requiring corrosion resistance and light weight and that aluminum is produced by the reduction of aluminum oxide using an electric current. The high energy cost of aluminum manufacture makes recycling aluminum profitable.

**Section 11.6** Students should know that the allotropes of carbon include graphite and diamond, which form **covalent network solids**. Many nonmetals form **molecular solids**, including sulfur, which forms puckered rings of 8 sulfur atoms, and phosphorous, which forms P<sub>4</sub> tetrahedra.

**Section 11.7** Students should know that many **ionic solids** consist of crystals with 1 ion forming one of the close-packed or closest-packed unit cells (fcc, bcc, simple cubic, or hexagonal) with the other ion occupying octahedral and tetrahedral holes in the crystal lattice. Unit-cell structures include rock salt, sphalerite, fluorite, and anti-fluorite. The unit-cell edge lengths and crystal structure of ionic solids can be used to calculate ionic radii and predict densities.

**Section 11.8** Students should know that heating selected solid inorganic compounds (such as clays, which are aluminosilicate minerals) to high temperature alters their chemical composition

and makes the materials harder, denser, and stronger. The resulting heat- and chemical-resistant materials (**ceramics**) are electrical insulators due to the large energy gap ( $E_g$ ) between their filled valence and empty conduction bands. The polymorphs of silica consist of  $\text{SiO}_4$  tetrahedra, each of which can share some or all its oxygen atoms with other tetrahedral, forming Si — O — Si bridges and two- and three-dimensional covalent networks. In **superconducting** ceramics, the electrical resistance of the material drops to zero below its **critical temperature** ( $T_c$ ).

**Section 11.9** Students should know that **X-ray diffraction** is an analytical method that records constructive and destructive interference of X-rays reflecting off different layers of atoms or ions in crystals. You should understand that the distances between layers can be calculated using the **Bragg equation**. X-ray diffraction makes it possible to determine the solid-state structure of crystalline solids.