Semiconductor Doping

Materials can be classified according to their ability to conduct electricity. A good *conductor* has a large number of free charge carriers that can move easily through the material, whereas an *insulator* has a small number of free charge carriers that are relatively immobile. *Semiconductors* exhibit electronic properties between those of insulators and those of conductors. The development of *band theory* uses basic physical principles to explain some of the properties of these three categories of materials.

Electron energy levels

As seen in the chapter "Atomic Physics," the electrons in an atom can possess only certain amounts of energy. For this reason, the electrons are often said to occupy specific *energy levels.* Electrons in a shell sometimes form a set of closely spaced energy levels. Normally, electrons are in the lowest energy level available to them. The specific arrangement of electrons in which all are in the lowest possible energy levels of an atom is called the atom's **ground state.**

If an atom absorbs sufficient energy from the environment, some of the atom's electrons can move to higher energy levels. The atom is then said to be in an **excited state.** If an electron absorbs so much energy that it is no longer bound to the atom, it is then called a *free electron.*

Band theory

Band theory uses the concept of energy levels to explain the mechanisms of conduction in many solids. When identical atoms are far apart, they have identical energy-level diagrams. No two electrons in the same system can occupy the same state. As a result, when two atoms are brought closer together, the energy levels of each atom are altered by the influence of the electric field of the other atom. **Figure 1** shows how two energy levels split when there are two atoms **(a),** four atoms **(b),** and many atoms **(c)** at different separation distances. In the case of two atoms, each energy level splits into two different energy levels, as shown in **Figure 1(a).** Notice that the energy difference between two new energy levels depends on the distance between the atoms.

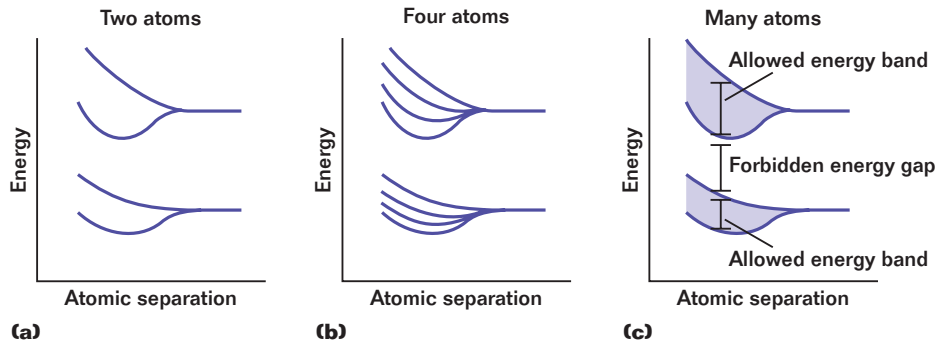

Figure 1
Energy levels split when two atoms are close together **(a).** Adding a few more nearby atoms causes further splitting **(b).** When many atoms interact, the energy levels are so closely spaced that they can be represented as energy bands **(c).**