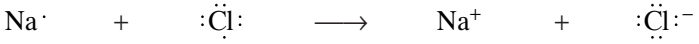
atom and a chlorine atom approaching each other. The two atoms are neutral and have one and seven valence electrons, respectively.

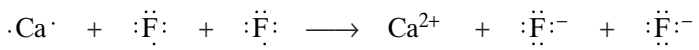
Sodium atom Chlorine atom

We have already seen that atoms of sodium and the other alkali metals readily lose one electron to form cations. And we have seen that atoms of chlorine and the other halogens readily gain one electron to form anions. The combination of sodium and chlorine atoms to produce one formula unit of sodium chloride can thus be represented as follows.



Sodium atom Chlorine atom Sodium cation Chloride anion

The transfer of an electron from the sodium atom to the chlorine atom transforms each atom into an ion with a noble-gas configuration. In the combination of calcium with fluorine, two fluorine atoms are needed to accept the two valence electrons given up by one calcium atom.



Calcium atom Fluorine atoms Calcium cation Fluoride anions

Characteristics of Ionic Bonding

Recall that nature favors arrangements in which potential energy is minimized. In an ionic crystal, ions minimize their potential energy by combining in an orderly arrangement known as a *crystal lattice* (see **Figure 13**). The attractive forces at work within an ionic crystal include those between oppositely charged ions and those between the nuclei and electrons of adjacent ions. The repulsive forces include those between like-charged ions and those between electrons of adjacent ions. The distances between ions and their arrangement in a crystal represent a balance among all these forces. Sodium chloride's crystal structure is shown in **Figure 14** below.

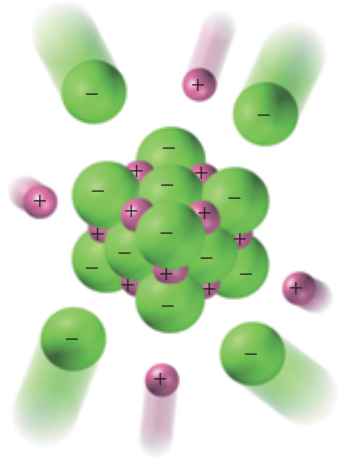
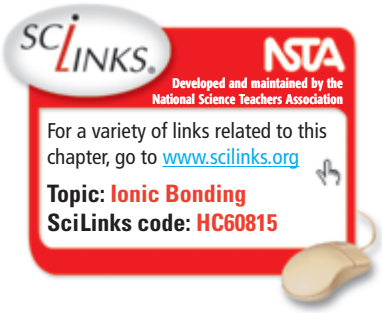
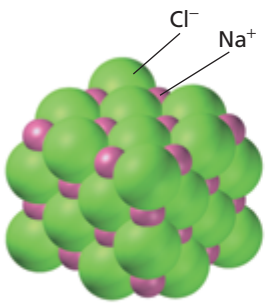
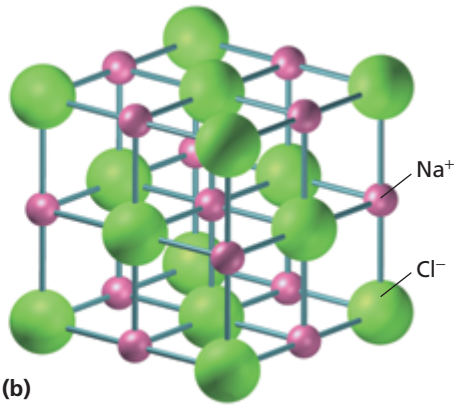


FIGURE 13 The ions in an ionic compound lower their potential energy by forming an orderly, three-dimensional array in which the positive and negative charges are balanced. The electrical forces of attraction between oppositely charged ions extend over long distances, causing a large decrease in potential energy.





(a)



(b)

FIGURE 14 Two models of the crystal structure of sodium chloride are shown. (a) To illustrate the ions' actual arrangement, the sodium and chloride ions are shown with their electron clouds just touching. (b) In an expanded view, the distances between ions have been exaggerated in order to clarify the positioning of the ions in the structure.