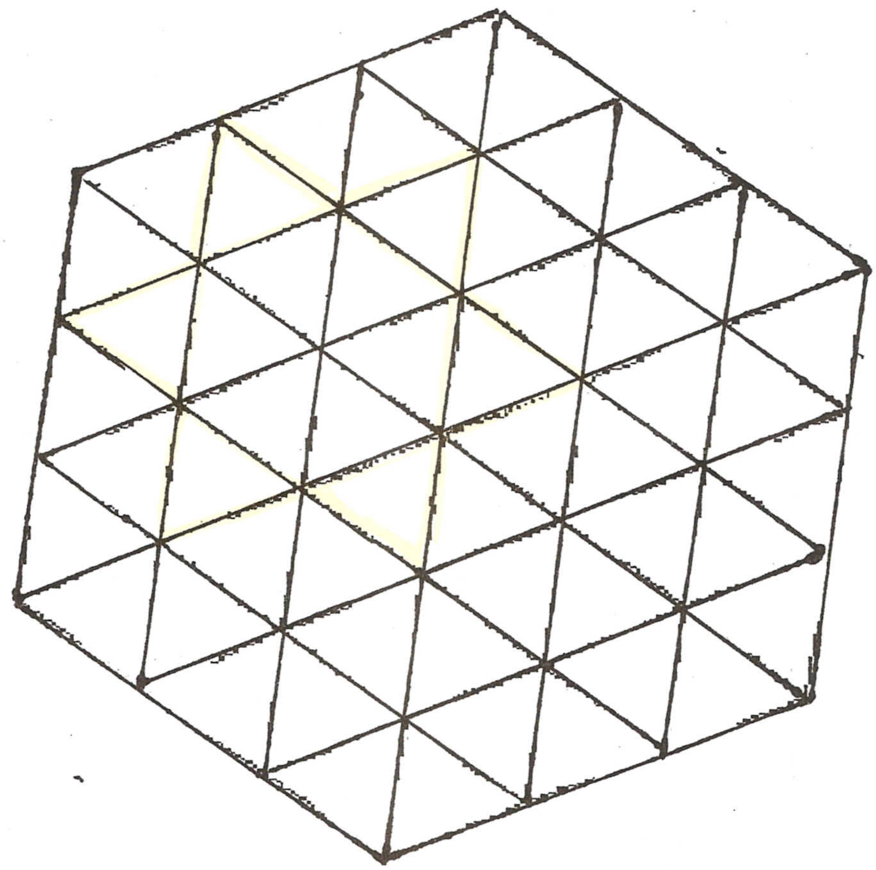
In the natrium chloride (NaCl) structure, the space lattice is face centered cubic (FCC). There are two such FCC lattices which are separated by one half of the body diagonal of the unit cube. One lattice is occupied by Na atoms, the other by Cl atoms. Each atom has 6 neares neighbors of the opposite kind and is bound to these 6 atoms which are arranged at the corners of the surrounding octahedron. The bonding is typically ionic.



Sodium Chloride - NACL
Crystal (A cube)

VIEwing from The corner of The crystal cube

Note stars of David and seven candlesticks Throughout

Figure 13·8
Curing salts are used to prevent bacterial growth in meat.

No conclusive evidence exists that nitrites themselves cause cancer. They can react with the hemoglobin in blood, however, to reduce the capacity of blood to carry oxygen. This condition is particularly serious in babies and unborn children.

Cured meats are not the only source of nitrite we encounter. Saliva contains nitrite, and nitrate that is present naturally in food and water is converted to nitrite in the intestines. Thus it is advisable to control nitrite consumption wherever possible. Some experts feel, however, that a total ban on the use of nitrites in cured meats could cause an outbreak of botulism. The amount of nitrite that can be used in foods is restricted by government regulations. Scientists are also looking for ways to inhibit the formation of nitrosoamines.

13·5 Properties of Ionic Compounds

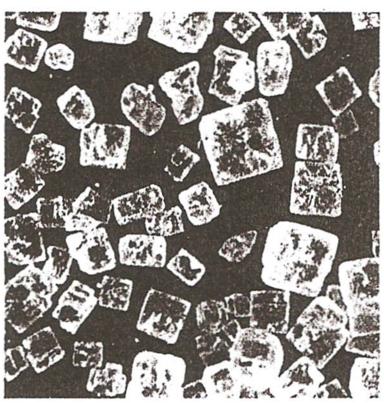
An ionic compound is characterized by a high-melting point, conductivity of electricity in the molten state, existence in a crystalline form, and tendency to dissolve in water.

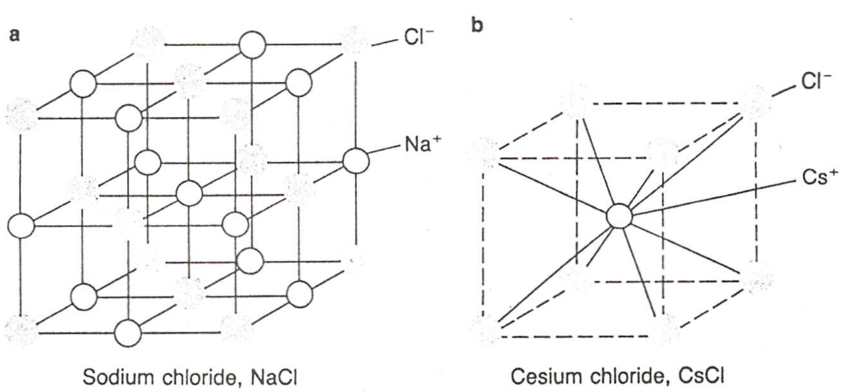
Most ionic compounds are crystalline solids at room temperature. *The component molecules, atoms, or ions of a crystal are arranged in repeating three-dimensional patterns.* The composition of a crystal of sodium chloride is typical. In solid NaCl each sodium ion is surrounded by six chloride ions and each chloride ion is surrounded by six sodium ions. In this arrangement each ion is attracted strongly to each of its neighbors and repulsions are minimized. The large attractive forces result in a very stable structure. This is reflected in the fact that NaCl and ionic compounds in general have very high melting temperatures.

The three dimensional arrangement of ions in NaCl is shown in Figure 13·9. Because each Na^+ ion is surrounded by six Cl^- ions, it has a coordination number of 6. *The* **coordination number** *gives the number of ions of opposite charge that surround each ion in a crystal.* Each Cl^- ion is surrounded by six Na^+ ions and also has a coordination number of 6.

Cesium chloride (CsCl) has a formula unit that is similar to NaCl. Both these compounds have cubic crystals but their internal crystal structures are different. Each Cs^+ ion is surrounded by eight Cl^- ions, and each Cl^- ion is surrounded by eight Cs^+ ions. Both the anion and cation in cesium chloride have a coordination number of 8.

Figure 13·9
Cesium chloride and sodium chloride both form clear cubic crystals. Nevertheless their internal crystal structures differ. The unit cell of sodium chloride is face-centered cubic. By contrast the unit cell of cesium chloride is body-centered cubic. How many chlorine atoms surround each sodium atom? How many chlorine atoms surround each cesium atom?





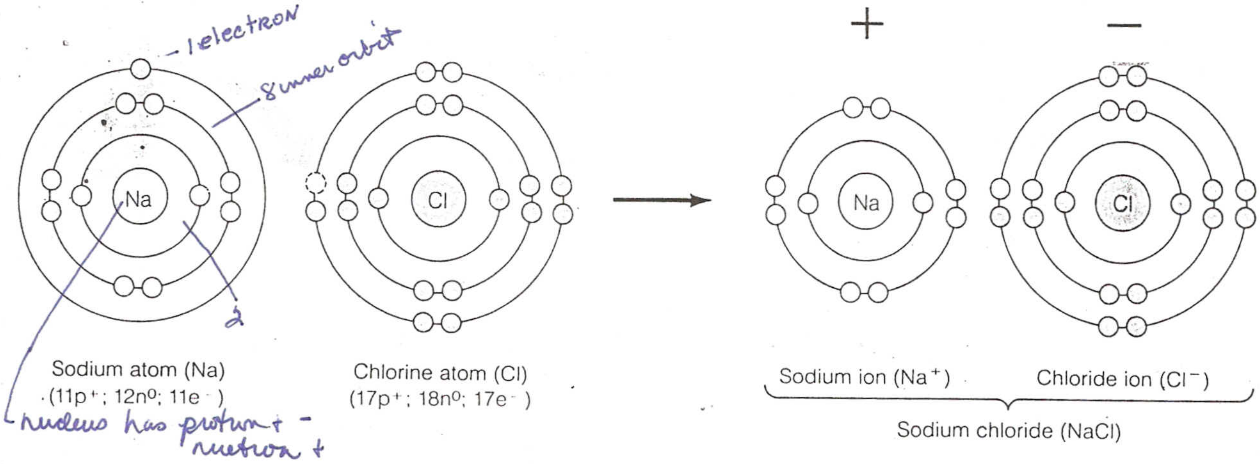


FIGURE 2.5
Formation of an ionic bond. Both sodium and chlorine atoms are chemically reactive because their valence shells are incompletely filled. Sodium gains stability by losing one electron, whereas chlorine becomes stable by gaining one electron. After electron transfer, sodium becomes a sodium ion (Na^+), and chlorine becomes a chloride ion (Cl^-). The oppositely charged ions attract each other.

electron is lost, shell 2 with eight electrons becomes the valence shell (outermost energy level containing electrons) and is full. Thus, by losing the lone electron in its third energy level, sodium achieves stability and becomes a cation (Na^+). On the other hand, chlorine, atomic number 17, needs only one electron to fill its valence shell. By accepting an electron, chlorine becomes an anion and achieves stability. When these two atoms interact, this is exactly what happens. Sodium donates an electron to chlorine, and the ions created in this exchange attract each other forming sodium chloride. Ionic bonds are commonly formed between atoms with one or two valence shell electrons (the metallic elements, such as sodium, calcium, and potassium) and atoms with seven valence shell electrons (such as chlorine, fluorine, and iodine). Most ionic compounds fall in the chemical category called *salts.*

In the dry state, ionic compounds such as sodium chloride do not exist as individual molecules. Instead, they form **crystals,** large arrays of cations and anions held together by ionic bonds (see Figure 2.11, page 39).

Sodium chloride is an excellent example of the difference in properties between a compound and its constituent atoms. Sodium is a silvery white metal, and chlorine in its molecular state is a poisonous green gas used to make bleach. However, sodium chloride is a white crystalline solid that we sprinkle on our food.

Covalent Bonds

Electrons do not have to be completely transferred for atoms to achieve stability. Instead, they may be *shared* so that each atom is able to fill its outer electron shell for at least part of the time. Electron sharing produces molecules in which the shared electrons constitute **covalent** (ko-va′lent) **bonds.**

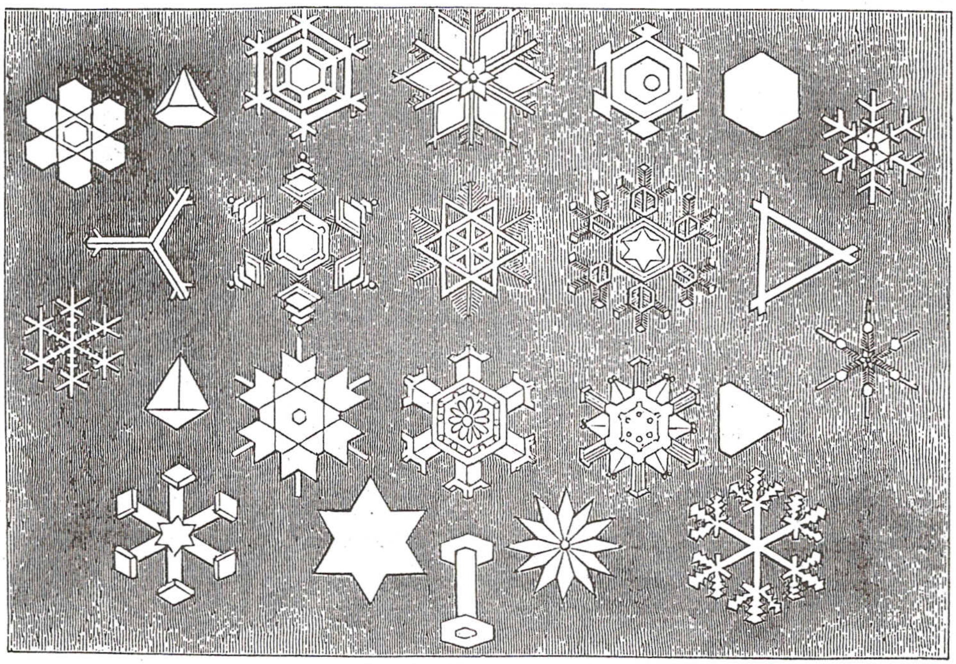
Hydrogen with its single electron can fill its only shell (shell 1) by sharing a pair of electrons with another atom. When it shares with another hydrogen, a molecule of hydrogen gas is formed. The shared electron pair orbits around the molecule as a whole, satisfying the stability needs of each atom. Hydrogen can also share an electron pair with different kinds of atoms to form a compound (Figure 2.6a). Carbon has four electrons in its outermost shell, but needs eight to achieve stability, whereas hydrogen has one electron, but needs two. When a methane molecule (CH_4) is formed, carbon shares four pairs of electrons with four hydrogen atoms (one pair with each hydrogen). Again, the shared electrons orbit and "belong to" the whole molecule, ensuring the stability of each atom. When atoms share one pair of electrons, a *single covalent bond* is formed (indicated by a single line connecting the atoms, such as H—H). But in some cases, atoms share two or three electron pairs (Figure 2.6b and c), resulting in *double* or *triple covalent bonds* (indicated by double or triple lines such as O=O or N≡N).

Polar and Nonpolar Molecules. In the covalent bonds discussed thus far, the shared electrons have been shared equally between the atoms of the molecule. The molecules formed are electrically balanced and are called **nonpolar molecules.** However, this is not always the case. When two or more atoms form covalent bonds, the resulting molecule always has a specific three-dimensional shape, with bonds formed at definite angles. A molecule's shape helps determine what other molecules or atoms it can interact with; it may also result in unequal electron pair sharthe college at Maryville, Tenn., and also at the Southwestern Theological Seminary at Maryville; was licensed by Union Presbytery in 1831; was ordained in 1833, and preached for Lebanon and Eusebia churches; took charge of New Prospect Church in 1836. Having organized Spring Place Church, he added that to his other places of preaching till 1853. He took charge of Ebenezer Church in 1855, where he labored until his death, June 22, 1859. Mr. Snoddy was a faithful and devoted minister of the Gospel. See Wilson, *Presb. Hist. Almanac*, 1861, p. 192.

Snotr, in Norse mythology, was the goddess of virtue and modesty, and the protectress of virtuous men.

Snow (שֶׁלֶג, *shéleg*, so called probably from its *glistening*; Sept. and New Test. *χιών*; but *δρόσος* in Prov. xxvi; Vulg. *nix*). The historical books of the Bible contain only two notices of snow actually falling (2 Sam. xxiii, 20; 1 Macc. xiii, 22), but the allusions in the poetical books are so numerous that there can be no doubt as to its being an ordinary occurrence in the winter months. Thus, for instance, the snow-storm is mentioned among the ordinary operations of nature which are illustrative of the Creator's power (Psa. cxlvii, 16; cxlviii, 8). We have, again, notice of the beneficial effect of snow on the soil (Isa. lv, 10). Its color is adduced as an image of brilliancy (Dan. vii, 9; Matt. xxviii, 3; Rev. i, 14), of purity (Isa. i, 18; Lam. iv, 7, in reference to the white robes of the princes), and of the blanching effects of leprosy (Exod. iv, 6; Numb. xii, 10; 2 Kings v, 27). In the book of Job we have references to the supposed cleansing effects of snow-water (ix, 30), to the rapid melting of snow under the sun's rays (xxiv, 19), and the consequent flooding of the brooks (vi, 16). The thick falling of the flakes forms the point of comparison in the obscure passage in Psa. lxviii, 14. The snow lies deep in the ravines of the highest ridge of Lebanon until the summer is far advanced, and indeed never wholly disappears (Robinson, iii, 531); the summit of Hermon also perpetually glistens with frozen snow (ibid. ii, 437). From these sources probably the Jews obtained their supplies for the purpose of cooling their beverages in summer (Prov. xxv, 13), as is still done (Hackett, *Illust. of Script.* p. 53). This allusion removes the apparent contradiction of this passage in Prov. xxvi, 1. As snow—that is, a fall of snow—in summer is unnatural and ill-timed, so honor is not seemly for a fool; but it is quite out of character, out of season. The "snow of Lebanon" is also used as an expression for the refreshing coolness of spring water, probably in reference to the stream of Siloam (Jer. xviii, 14). Lastly, in Prov. xxxi, 21, snow appears to be used as a synonym for winter or cold weather. The liability to snow must of course vary considerably in a country of such varying altitude as Palestine. Josephus notes it as a peculiarity of the low plain of Jericho that it was warm there even when snow was prevalent in the rest of the country (*War*, iv, 8, 3). At Jerusalem snow often falls to the depth of a foot or more in January and February, but it seldom lies long (Robinson, i, 429). At Nazareth it falls more frequently and deeply, and it has been observed to fall even in the maritime plain at Joppa and about Carmel (Kitto, *Phys. Hist.* p. 210). A comparison of the notices of snow contained in Scripture and in the works of modern travellers would, however, lead to the conclusion that more fell in ancient times than at the present day. At Damascus snow falls to the depth of nearly a foot, and lies at all events for a few days (Wortabet, *Syria*, i, 215, 236). At Aleppo it falls, but never lies for more than a day (Russell, i, 69).

Scientifically, snow is nothing more than the frozen visible vapor of which the clouds are formed. A quantity of very minute crystals of ice having been formed, they are enlarged by the condensation and freezing of vapor, and, merging together, constitute flakes, which increase in size during their descent. In equatorial regions snow is unknown at the ocean level, and in all latitudes less than thirty-five degrees it is rare; but it is found in all latitudes in the higher regions of the atmosphere. It would scarcely be supposed that the broad flakes of snow which every blast of wind blows hither and thither as it lists are perfectly formed collections of crystals, delicate in their structure, and regular in their measurement. Flakes of snow are best observed when placed upon objects of a dark color, cooled below the freezing-point, a method first described by Kepler, who expressed the highest admiration of their structure. The minute crystals exhibit an endless di-



Crystals of Snow, magnified.