

## The Mole

The mole is the SI unit for amount of substance. A **mole** (abbreviated mol) is the amount of a substance that contains as many particles as there are atoms in exactly 12 g of carbon-12. The mole is a counting unit, just like a dozen is. We don't usually order 12 or 24 ears of corn; we order one dozen or two dozen. Similarly, a chemist may want 1 mol of carbon, or 2 mol of iron, or 2.567 mol of calcium. In the sections that follow, you will see how the mole relates to masses of atoms and compounds.

## Avogadro's Number

The number of particles in a mole has been experimentally determined in a number of ways. The best modern value is  $6.022\,1367 \times 10^{23}$ . This means that exactly 12 g of carbon-12 contains  $6.022\,1367 \times 10^{23}$  carbon-12 atoms. The number of particles in a mole is known as Avogadro's number, named for the nineteenth-century Italian scientist Amedeo Avogadro, whose ideas were crucial in explaining the relationship between mass and numbers of atoms. **Avogadro's number**— $6.022\,1367 \times 10^{23}$ —is the number of particles in exactly one mole of a pure substance. For most purposes, Avogadro's number is rounded to  $6.022 \times 10^{23}$ .

To get a sense of how large Avogadro's number is, consider the following: If every person living on Earth (5 billion people) worked to count the atoms in one mole of an element, and if each person counted continuously at a rate of one atom per second, it would take about 4 million years for all the atoms to be counted.

## Molar Mass

An alternative definition of *mole* is the amount of a substance that contains Avogadro's number of particles. Can you figure out the approximate mass of one mole of helium atoms? You know that a mole of carbon-12 atoms has a mass of exactly 12 g and that a carbon-12 atom has an atomic mass of 12 amu. The atomic mass of a helium atom is 4.00 amu, which is about one-third the mass of a carbon-12 atom. It follows that a mole of helium atoms will have about one-third the mass of a mole of carbon-12 atoms. Thus, one mole of helium has a mass of about 4.00 g.

The mass of one mole of a pure substance is called the **molar mass** of that substance. Molar mass is usually written in units of g/mol. The molar mass of an element is numerically equal to the atomic mass of the element in atomic mass units (which can be found in the periodic table). For example, the molar mass of lithium, Li, is 6.94 g/mol, while the molar mass of mercury, Hg, is 200.59 g/mol (rounding each value to two decimal places).

A molar mass of an element contains one mole of atoms. For example, 4.00 g of helium, 6.94 g of lithium, and 200.59 g of mercury all contain a mole of atoms. Figure 3-10 shows molar masses of three common elements.



(a)



(b)



(c)

**FIGURE 3-10** Shown is approximately one molar mass of each of three elements: (a) carbon (as graphite), (b) iron (nails), and (c) copper (wire).

## Gram/Mole Conversions

Chemists use molar mass as a conversion factor in chemical calculations. For example, the molar mass of helium is 4.00 g He/mol He. To