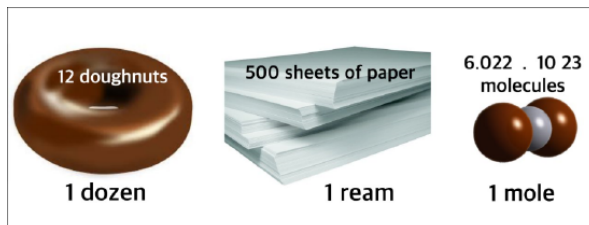


## 2.8: The Mole



Example shows 12 doughnuts as one dozen, 500 sheets of paper as 1 ream, and  $6.022 \times 10^{23}$  molecules as 1 mole.

Because atoms and molecules are extremely small, there are a great many of them in any macroscopic sample. The  $1 \text{ cm}^3$  of mercury referred to in [the introduction to moles \(opens in new window\)](#) would contain  $4.080 \times 10^{22}$  mercury atoms, for example, and the  $3.47 \text{ cm}^3$  of bromine would contain twice as many ( $8.160 \times 10^{22}$ ) bromine atoms. The very large numbers involved in counting microscopic particles are inconvenient to think about or to write down. Therefore chemists have chosen to count atoms and molecules using a unit called the mole. One **mole** (abbreviated mol) is  $6.022 \times 10^{23}$  of the microscopic particles which make up the substance in question. Thus  $6.022 \times 10^{23}$  Br atoms is referred to as 1 mol Br. The  $8.160 \times 10^{22}$  atoms in the sample we have been discussing would be:

$$\frac{8.160 \cdot 10^{22}}{6.022 \cdot 10^{23} \text{ mol Br}} = 0.1355 \text{ mol Br}$$

The idea of using a large number as a unit with which to measure how many objects we have is not unique to chemists. Eggs, doughnuts, and many other things are sold by the dozen—a unit of twelve items. Smaller objects, such as pencils, may be ordered in units of 144, that is, by the gross, and paper is packaged in reams, each of which contains 500 sheets. A chemist who refers to 0.1355 mol Br is very much like a bookstore manager who orders  $2\frac{1}{2}$  dozen sweat shirts, 20 gross of pencils, or 62 reams of paper.

There is a difference in degree, however, because the chemist's unit,  $6.022 \times 10^{23}$ , is so large. A stack of paper containing a mole of sheets would extend more than a million times the distance from the earth to the sun, and  $6.022 \times 10^{23}$  grains of sand would cover all the land in the world to a depth of nearly 2 ft. Obviously there are a great many particles in a mole of anything.

Why have chemists chosen such an unusual number as  $6.022 \times 10^{23}$  as the unit with which to count the number of atoms or molecules? Surely some nice round number would be easier to remember. The answer is that *the number of grams in the mass of 1 mol of atoms of any element is the atomic weight of that element*. For example, 1 mol of mercury atoms not only contains  $6.022 \times 10^{23}$  atoms, but its mass of 200.59 g is conveniently obtained by adding the unit gram to the [Table of Atomic Weights](#). Some other examples are

$$1 \text{ mol H contains } 6.022 \times 10^{23} \text{ H atoms; its mass is 1.008 g.} \quad (2.8.1)$$

$$1 \text{ mol C contains } 6.022 \times 10^{23} \text{ C atoms; its mass is 12.01 g.} \quad (2.8.2)$$

$$1 \text{ mol O contains } 6.022 \times 10^{23} \text{ O atoms; its mass is 16.00 g.} \quad (2.8.3)$$

$$1 \text{ mol Br contains } 6.022 \times 10^{23} \text{ Br atoms; its mass is 79.90 g.} \quad (2.8.4)$$

*Here and in subsequent calculations atomic weights are rounded to two decimal places, unless, as in the case of H, fewer than four significant figures would remain.*

The mass of a mole of *molecules* can also be obtained from atomic weights. Just as a dozen eggs will have a dozen whites and a dozen yolks, a mole of CO molecules will contain a mole of C atoms and a mole of O atoms.

The mass of a mole of CO is thus:

$$\text{Mass of 1 mol C} + \text{mass of 1 mol O} = \text{mass of 1 mol CO}$$

$$12.01 \text{ g} + 16.00 \text{ g} = 28.01 \text{ g}$$

The molecular weight of CO (28.01) expressed in grams is the mass of a mole of CO. Some other examples are in Table 2.8.1.

Table 2.8.1: Molecular Weight

Molecule	Molecular Weight	Mass of 1 Mol of Molecules
Br <sub>2</sub>	$2(79.90) = 159.80$	159.80 g
O <sub>2</sub>	$2(16.00) = 32.00$	32.00 g
H <sub>2</sub> O	$2(1.008) + 16 = 18.02$	18.02 g
HgBr <sub>2</sub>	$200.59 + 2(79.90) = 360.39$	360.39 g
Hg <sub>2</sub> Br <sub>2</sub>	$2(200.59) + 2(79.90) = 560.98$	560.98 g

It is important to specify to what kind of particle a mole refers. A mole of Br atoms, for example, has only half as many atoms (and half as great a mass) as a mole of Br<sub>2</sub> molecules. It is best not to talk about a mole of bromine without specifying whether you mean 1 mol Br or 1 mol Br<sub>2</sub>.

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