6.1: The Mole

When objects are small or come in larger quantities, it is often inconvenient, inefficient, or even impossible to deal with the objects one at a time. For these reasons, we often deal with small objects or large quantities in groups, and have even invented names for various numbers of objects. The most common of these is "dozen" which refers to 12 objects. We frequently buy objects in groups of 12, like donuts or pencils. Other items such as bottle rockets – a type of fireworks – are sold in packages of 144, which is called a "gross", another name for a dozen dozen ($12^2 = 144$).

Figure 6.1.1: One dozen donuts. (Racool; FreeRange Stock Photos)

Avogadro's Number and the Mole

Chemists use a quantity called the **mole** to count items. One mole of any item contains 602,200,000,000,000,000,000,000, or 6.022×10^{23}, of those items. When writing numbers in scientific notation, or when seeing a bunch of zeroes at the end of a number, it is easy to lose the context of a number's sheer size.

For example, one mole of eggs (6.022×10^{23} eggs), the kind purchased at a grocery store, would be enough to cover the entire planet 60 miles deep with eggs! Or, perhaps you prefer to think of quantities in terms of cold, hard cash. According to the United States Census Bureau Population Clock, there were over 334,630,000 people living in the U.S. in April 2023. With one mole dollars ($\$6.022\times10^{23}$) available, it would be possible to give every person living in the U.S. $1,000,000 per *every single second* of their lives for a duration of 57 years and 1 month! Indeed, this number is quite large!

What could possibly be measured with such an enormous number? If you said atoms or molecules, you would be correct! Individual atoms and molecules are too small to be seen, counted, or weighed on their own. However, if one were to gather together enough atoms or molecules, they may be weighed and even counted.

The **mole**, abbreviated as **mol**, is the base SI unit for the amount of substance, defined as exactly 6.02214076×10^{23} particles (atoms, molecules, ions, or electrons). The current definition was adopted in November 2018, revising its old definition based on the number of atoms in 12 grams of carbon-12 ($^{12}_{6}C$). For most purposes, 6.022×10^{23} provides an adequate number of significant figures. Just as 1 mole of atoms contains 6.022×10^{23} atoms, 1 mole of eggs contains 6.022×10^{23} eggs.

6.022×10^{23} is also called **Avogadro's number**, after the 19th-century Italian scientist who first proposed a relationship between the volumes of gases and the numbers of particles they contain. There is a particular reason that this number was chosen and this reason will become clear as we proceed.