Article: What is a mole?

When wildlife biologists talk about moles, they're usually referring to the tiny, gray rodents that dig underground to find delicious earthworms. But when chemists talk about moles, they're usually referring to a scientific term. The term 'mole' represents a number, in the same way the word 'dozen' represents 12 of something. In this case, one mole represents the enormous (and slightly strange) number, 6.02×10^{23}.

This is a huge number! To help you and any wildlife biologists reading this module get a sense of just how many things are in one mole, we can use an analogy with another small, gray rodent: the gray squirrel (Figure 1). One gray squirrel weighs roughly 500 grams, or as much as a hardback book. One dozen gray squirrels weigh about 6,000 grams, or a little more than a medium-sized bowling ball. And one *mole* of gray squirrels weighs 301,000,000,000,000,000,000,000,000 grams—more than four times the mass of the moon!

Obviously, the mole is not a term we need for most things in daily life. Instead of being used for things we encounter in daily life, the mole is used by scientists when talking about enormous numbers of particles like atoms, molecules, and electrons—although the mole's usefulness goes beyond being a helpful scientific term. The mole does more than represent a big number: It provides a key link for converting between the number (amount) of a substance, and its mass.

The mole and molar mass

The International Committee for Weights and Measures—a group that defines the metric system's unitsof measurement (for more information, see our module on The Metric System)—defines one mole as the number of atoms in exactly 12 grams of carbon-12 (^{12}C, Figure 2). Experiments counting the number of ^{12}C atoms in a 12-gram sample have determined that this number is $6.02214076 \times 10^{23}$. Regardless of whether the substance is ^{12}C, electrons, or gray squirrels, one mole represents the same *number* of each of these things.
Scientists have then defined the molar mass of a substance as the mass of $6.02214076 \times 10^{23}$ units of that substance. So, the molar mass of gray squirrels is 301,000,000,000,000,000,000,000,000 grams. With squirrels, this is not very useful. However, it is quite useful if we apply it to other substances, especially elements. By standardizing the number of atoms in a sample of an element, we also get a standardized mass for that element that can be used to compare different elements and compounds to one another. ^{12}C's molar mass is 12 grams, which represents the combined mass of 6.02×10^{23} ^{12}C atoms.

However, other elements have different molar masses; for example, 6.02×10^{23} sulfur-32 (^{32}S) atoms have a mass together of 31.97 grams, which is ^{32}S's molar mass.
Along with telling us the mass of one mole of an element, molar mass also acts as a conversion factor between the mass of a sample and the number moles in that sample. For example, 24 grams of ^{12}C atoms would be equal to two moles since 24 grams divided by the mass of one mole (12) equals 2. Further, Avogadro's number acts as the conversion factor for converting between the number of moles in a sample and the actual number of atoms or molecules in that sample. Extending our example, two moles of ^{12}C atoms contains 2 times 6.02×10^{23} atoms, which equals 12.04×10^{23} atoms, which can be written as 1.204×10^{24} atoms.

True or False: Text Evidence

Write if each statement is true or false, then provide evidence from the article that proves your answer!

1. One mole equals 6.02×10^{23}. _____
   Evidence:

2. The mole represents atoms, molecules, and ions._____
   Evidence:

3. A mole is defined as the number of atoms in exactly 16.0 grams of oxygen in oxygen-16._____
   Evidence:

4. One mole of all elements have the same mass. _____
   Evidence:

5. Moles can be used to convert between moles and grams and moles and number of particles. _____
   Evidence: