Mole Day and the Meaning of the Mole

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Most chemistry students and teachers are aware of “Mole Day” – October 23. In fact, it has also been said that there is a “mole minute” at 6:02 AM on October 23. Where did the idea for this “holiday” come from? Of course, it is from Avogadro’s number, 6.02 x 10^{23}. The unfortunate implication is that a mole is the same as Avogadro’s number. But is this really the case?

The mole, abbreviated “mol,” is an amount of substance whereas Avogadro’s number is just that, a number.

To understand the distinction, consider how you buy groceries. Because there is no specific unit for flour, it cannot be counted, so it is sold by amount. This amount might be measured by either mass or weight. You can purchase a pound of flour, or two pounds, or five pounds, and so on. Eggs, however, are items that can be counted. Even though they could be sold by mass or weight, they usually are not. Instead, they are sold by number, say a dozen.

For substances that exist in individual units (i.e. those that can be counted) you can determine a relationship between the amount (mass) of a sample and the number of items in that sample. This is the key to understanding the relationship between a mole and Avogadro’s number. A mole is that amount of substance that contains Avogadro’s number of items of that substance.

Returning to the grocery example…on one carton of “Grade A Large Brown Eggs” is written “One Dozen NET WT 24 OZ (1 LB 8 OZ) 680g.” The buyer is purchasing one dozen eggs that have a total weight of 24 oz. and a mass of 680 g. The number of eggs is 12 and the amount is 680 g. Unlike flour or hamburger, eggs can be measured and sold by either number or by amount.

If the mass of a dozen eggs is 680 g, the average mass of one egg is 57 g or, to one significant figure, 6 x 10^1 g. Since the mole is that amount of a substance that contains Avogadro’s number of individual items, a mole of eggs would be the mass of 6 x 10^{23} eggs*. This can be found by multiplying Avogadro’s number by the mass of one egg.

$$\left(6\times10^{23}\,\frac{\text{eggs}}{\text{mol}}\right)\times\left(6\times10^{1}\,\frac{\text{g}}{\text{egg}}\right)=4\times10^{25}\,\frac{\text{g eggs}}{\text{mol eggs}}$$

This huge mass is about 1% of the Earth’s mass! A mole of eggs could never exist on Earth. The units on this answer are correct, but many would consider “eggs” to be superfluous. However, beginning students should be told explicitly that both the “g” and “mol” function as adjectives for the same kind of matter, “eggs,” and no other kind of matter. Usually the unit is written as “g/mol” and the reader is expected to realize the kind of matter to which both the “g” and “mol” refer from the context of the writing. Taken out of context, the unit becomes an enigma unless the writer specifies “g of eggs per mole of eggs.”

The average mass of a hydrogen atom is 1.67372 x 10^{-24} g/atom. Therefore, a mole of hydrogen atoms would be the mass of 6.02214 x 10^{23} atoms** or

$$\left(6.02214\times10^{23}\,\frac{\text{H atoms}}{\text{mol}}\right)\times\left(1.67372\times10^{-24}\,\frac{\text{g}}{\text{H atom}}\right)=1.00794\,\frac{\text{g}}{\text{mol}}.$$

Unlike eggs, a mole of hydrogen atoms could easily be held in your hand. Note that the unit is written “g/mol,” and the reader is expect to realize from the context that the writer is speaking of hydrogen atoms here and to no other kind of matter.

Compared to your own mass, the mass of a mole of eggs is huge, but the mass of a mole of hydrogen atoms is small. The mass of a mole is dependent on the mass of an individual unit of the substance, but Avogadro’s number is always 6.02214 x 10^{23}. So remember on Mole Day that a mole and Avogadro’s number are not the same!

* Only one significant figure is kept here for Avogadro’s number because there was only one significant figure in the mass of an egg.

** Six significant figures are used in Avogadro’s number since the mass of a hydrogen atom is known to six significant figures.