

Teacher Background

Chapter 5, Lesson 5

The idea of measuring an “equal amount” of two substances can have different meanings depending on how the amounts will be used. For example, let’s say you wanted an equal amount of carbon and calcium. If you measured out 5 grams of each, you would have the same amount of matter of each substance but you would not have the same number of atoms. Since carbon is lighter (lower atomic mass) than calcium, there would be more *atoms* of carbon in 5 grams of carbon than calcium *atoms* in 5 grams of calcium.

Counting atoms

But what if you needed to measure the same number of carbon and calcium atoms? There is a way of doing this but you need to know the atomic mass of carbon and calcium. You also need to apply a concept related to the *mole* or *Avogadro’s* number.

A mole is a huge number used to count the enormous number of atoms or molecules in even a small sample of matter. A mole is equal to 6.02×10^{23} . The mole concept and the atomic mass work together in an interesting way to allow you to determine the number of atoms or molecules in a sample of a substance.

Here’s how it works: Carbon has an atomic mass of 12. That means that 12 grams of carbon contains 6.02×10^{23} carbon atoms. Another way of saying this is that one mole of carbon atoms has a mass of 12 grams.

Calcium has an atomic mass of 40. This means that 40 grams of calcium contains 6.02×10^{23} calcium atoms. Another way of saying this is that one mole of calcium atoms has a mass of 40 grams.

So to get an equal number of carbon and calcium atoms, you could weigh out 12 grams of carbon and 40 grams of calcium. You could also weigh out $\frac{1}{2}$ the amount of each such as 6 grams of carbon and 20 grams of calcium. As long as you use the same fraction or ratio for both, you could measure larger or smaller amounts and you would always have the same number of atoms.

Counting molecules

The same process works for molecules just like it does for atoms but you add the atomic mass for each atom in the molecule. For example, water is made of one oxygen atom and two hydrogen atoms. The atomic mass for oxygen is 16. The atomic mass for hydrogen is 1. So, the mass of a water molecule is $16 + 1 + 1 = 18$. This means that 18 grams of water contains 6.02×10^{23} water molecules.

How about isopropyl alcohol? Isopropyl alcohol is C_3H_8O . This means that the mass of the molecule is $3(12) + 8(1) + 16 = 36 + 8 + 16 = 60$. This means that 60 grams of isopropyl alcohol contains 6.02×10^{23} isopropyl alcohol molecules. Another way of saying it is that one mole of isopropyl alcohol molecules has a mass of 60 grams.

So, you need 60 grams of isopropyl alcohol to have the same number of molecules as there are water molecules in only 18 grams of water.

If you wanted to do an evaporation test between water and isopropyl alcohol in which you compared the same number of molecules of each, you could do it. You would just need to use a mass of alcohol and a mass of water that are in a ratio of 60 to 18. The activity does not call for this but if you compared the evaporation of 6 grams of isopropyl alcohol to 1.8 grams of water, the evaporation of the alcohol would be faster.