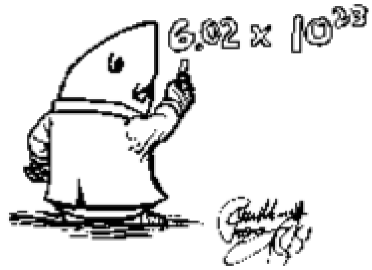
THE MOLE



We often use terms to describe a number of an item, like a dozen doughnuts or eggs. In the case of atoms, we do the same, but instead of 12 = 1 dozen, we need a much bigger number because atoms are so small it takes an incredibly huge number of them to make a visible amount.

A smart chemistry dude by the name of Amadeo Avogadro came up with the calculations to determine the idea of a mole. If you take a 12g mass of carbon-12 atoms and divide it by the mass of one carbon-12 atom, about 1.99 x 10^{-23} g, the value comes out to be a huge number **6.02 x 10^{23}** (This is a rounded number)

This number is now known as Avogadro's Number. It is the number of particles in one mole. We can use particles to mean atoms, ions, formula units, molecules or even green peas. Is Mrs.Simmons losing it? Green peas? Just read this to get an idea of how big a number it really is!

The Green Pea Analogy

If you selected a hundred (10^2) average-sized peas, you would find that they occupy roughly a volume of 20 cm^3 . A million (10^6) peas are just enough to fill an ordinary household refrigerator and a billion (10^9) peas will fill a three bedroom house from basement to attic. A trillion (10^{12}) peas will fill a thousand houses, the number you might find in a medium-sized town. A quadrillion (10^{15}) peas will fill all the buildings in one of our larger cities such as Calgary or Edmonton.

Obviously you will run out of buildings very soon. Let us try a larger measure, for instance the province of Alberta. Suppose that there is a blizzard over Alberta, but instead of snowing snow, it snows peas. Alberta is covered with a blanket of peas about one metre deep all the way from Saskatchewan out to British Columbia, and all the way from the United States to the Northwest Territories. This blanket of peas drifts over the roads and banks up against the sides of the houses, and covers all the fields and forests. Think of flying across the province with the blanket of peas extending out as far as you can see. This gives you an idea of our next number. There will be in this blanket about a quintillion (10^{18}) peas.

Imagine that this blizzard of peas falls over the entire land- North America, Africa, South America, Europe, Australia, and Asia. All of the continents are covered with peas one metre deep. This global blanket will contain sextillion (10^{21}) peas. Then imagine that the oceans are frozen over and the blanket of peas covers the entire land and sea area of Earth. Go out among the neighbouring stars and collect 250 planets the size of Earth and cover each of these with a blanket of peas one metre deep.

Then you have a mole of peas.

Furthermore, go out into the farthest reaches of the Milky Way, and collect 250,000 planets, each the size of Earth. Cover each one with a blanket of peas one metre deep. You now have cotillion (10^{27}) - a number corresponding to the number of atoms in your body.

Cool huh?

Anyway, we can convert among numbers of particles, Avogadro's number, and moles by using a triangle. "**P" stands for number of particles (atoms, ions, molecules, etc.) "A" stands for Avogadro's number 6.02 x 10^{23} , and "n" stands for number of moles.**

Simply cover what you are looking for, and perform the operation left in the triangle.

Using this simple technique, calculate the following:

1. How many moles are in 7.2 x 10^{12} atoms?

2. 0.456 mol of iron is how many atoms?

3. How many molecules of sugar are in 1.25 mol?

4. 1.8×10^{36} ions represents how many moles?

Instead of dealing with individual atoms or molecules, chemists deal in mole amounts, and usually measure things by mass or volume.

How do we get from mass to moles?

In order to go from mass to moles, we need to work with something called the **molar mass (M)**. The molar mass is the mass of one mole (duh). For elements we can look at the periodic table to see the rounded value of molar mass. The molar mass is located in the top right corner of each square of your periodic table

Example - the molar mass of Fe (iron) is 55.85 g/mol (grams per mole)

What do we do for molar mass of compounds? We use the formula and the molar masses in the periodic table to help us.

Example: Calculate the molar mass of water

1. Write the formula H_2O
2. List the numbers of each element in the compound 2 H
   1 O
3. Multiply each number by the molar mass of the element
   2 H = 2 x 1.01 g/mol = 2.02 g/mol
   1 0 = 1 x 16.00 g/mol = 16.00 g/mol

4. Add them together

$$\begin{array}{r} 2.02 \text{ g/mol} \\ + \underline{16.00 \text{ g/mol}} \\ 18.02 \text{ g/mol} \end{array}$$

The molar mass of water is 18.02 g/mol

Try this one:

Find the molar mass of $(NH_4)_3PO_4$ (Remember a number outside brackets means that number times everything inside)

Try this:

Find the molar mass of barium hydroxide octahydrate

Summary for finding molar mass:

- write the chemical formula for the compound
- list the number of particles for each element
- multiply each number from step 2 by the molar mass for that element
- add all products ALL MOLAR MASS VALUES MUST SHOW A PRECISION OF TWO DECIMAL PLACES
- write your answer showing the g/mol units

To find the number of moles or do mass calculations for compounds and elements we can use another triangle. In this one, "**n" still means number of moles, "m" means mass and "M" means molar mass of the compound or element**

Try these:

1. How many moles of copper (II) sulfate pentahydrate in 550.6 g?

2. 1.6×10^{-4} mol of $KMnO_4$ has what mass?

There's one more triangle to remember, and again it goes back to our Italian dude, Avogardo. He also discovered that one mole of any gas at the same conditions had exactly the same volume. It doesn't matter what the gas is, CH_4 or O_2 or anything, it will always occupy the same volume under standard conditions. **<u>YOU CAN ONLY USE THIS FOR GASES AT STP!!!!!!!</u>**

In our chemistry course we use STP conditions. STP, known as Standard Temperature and Pressure, is $0^{o}C$ and 101.3 kPa. It is known that any mole of gas at STP has a volume of 22.4 L.

This is called **<u>molar volume</u>** and its symbol is **"V"**. Therefore we can convert between number of moles ("n") , volume ("v") and molar volume ("V") by using yet another triangle!

Try these:

1. What if the volume of 1.65 mol of helium gas at STP?

2. How many moles of oxygen gas are in 25.6 L?