AVOGADRO'S NUMBER – What's up with that?

One important property of a mole is that it means a definite number of particles just like a dozen means a number of particles. While a dozen is only 12 particles a **mole is a much larger number—6.02×10^{23} particles.** Elements generally exist as the particles we call atoms. **A mole of carbon contains 6.02×10^{23} atoms of carbon.** A mole of helium contains 6.02×10^{23} atoms of helium. A mole of sodium contains 6.02×10^{23} atoms of sodium. A mole of gold contains 6.02×10^{23} atoms of gold. However, **we have learned about seven elements that exist as diatomic molecules—H_2, N_2, O_2, F_2, Cl_2, Br_2, and I_2. For these elements one mole is 6.02×10^{23} molecules. That is, 6.02×10^{23} molecules of hydrogen is one mole of hydrogen,** 6.02×10^{23} molecules of nitrogen is one mole of nitrogen, 6.02×10^{23} molecules of oxygen is one mole of oxygen, etc.

While atoms are the smallest part of an element that still retains the properties of that element, molecules are the smallest parts of covalent compounds that still retain the properties of that compound. (For ionic compounds the smallest part is a combination of + and – ions but for now let's just consider them to be "molecules".) Therefore, one mole of a compound contains 6.02×10^{23} molecules of that compound. **One mole of water contains 6.02×10^{23} molecules of water**, one mole of carbon dioxide contains 6.02×10^{23} molecules of carbon dioxide, one mole of ammonia contains 6.02×10^{23} molecules of ammonia, one mole of sodium chloride contains 6.02×10^{23} "molecules" of sodium chloride, etc. (The number 6.02×10^{23} is a measurement, not a definition, and is only good for three significant figures.)

In all of the above examples one mole of any substance contained the same number of particles. But remember, they all had different masses. The mass of one mole of each material was equal to the gram formula or molecular mass. (This is the same idea as the mass of a dozen. A dozen eggs, a dozen bricks, a dozen dump trucks all contain twelve items but the mass of a dozen eggs is certainly much different than the mass of a dozen bricks which is much different from the mass of a dozen dump trucks!)

The number **6.02×10^{23} is known as Avogadro's number** in honor of an Italian Professor of physics, Amadeo Avogadro, who did considerable work on the development of atomic theory and the mole concept in about 1810. Given this number we can calculate the number of particles in a known number of moles or the number of moles in a given number of particles.

EXAMPLE: How many molecules of water are there in 3.00 moles of water?

$$\text{\# molecules } H_20 = 3.00 \text{ moles } H_20 \times \frac{6.02 \times 10^{23} \text{ molecules of } H_20}{1 \text{ mole } H_20} = \mathbf{1.81 \times 10^{24} \text{ molecules } H_20}$$

EXAMPLE: How many moles of neon are there in 2.408×10^{24} atoms of neon?

$$\text{\# moles Ne} = 2.408 \times 10^{24} \text{ atoms Ne} \times \frac{1 \text{ mole Ne}}{6.02 \times 10^{23} \text{ atoms of Ne}} = \mathbf{4.00 \text{ moles Ne}}$$

USE AVOGADRO'S NUMBER TO SET-UP AND SOLVE THE FOLLOWING PROBLEMS. Show your work!

How many molecules are there in:

1. 2.00 moles of ammonia?

2. 0.50 moles chlorine?

3. 0.250 moles oxygen?

4. 4.00 moles of sulfur dioxide?

5. 2.50 moles of methane?

How many moles are there in:

6. 1.505×10^{24} molecules of sucrose sugar (C6H12O6)?

7. 1.806×10^{24} molecules of bromine?

8. 3.01×10^{24} atoms of argon?