The Mole and Avogadro's Number

Chapter 9

History

- About 200 years ago scientists needed a unit of measure that connected the mass of a molecule or atom with how many of them there were.
- Amadeo Avogadro proposed his hypothesis in 1811. At that time, there was no data on the number of particles in a mole, or an agreement on any atomic weights or the standard.

Avogadro's Law

- The number of particles of a gas of equal volumes as equal pressures and temperatures was a constant regardless of the gas.
- Inside a container of gas is some number of particles. He had no idea what the number was, but he thought it was a constant if the temperature and pressure were the same. He named this number a mole.
- He started to react his one mole of gas with other elements and started determining what one mole of those elements were.
- He measured the mass of a mole of different elements. This is atomic mass.

Amadeo Avogadro

- Advances in science led to a number that was named in Avogadro's honor.
- Avogadro never knew what the number was.
- We use ***6.022 x 10^{23}***. The current value is 6.022 141 99 x 10^{23}.

The Mole

- Analogy of size - Suppose that the entire state of Texas, with an area of 262,000 square miles, were covered with a layer of fine sand 50 feet thick, each grain of sand being 1/100 of an inch in diameter. There would then be Avogadro's number of sand particles in this immense sandpile.
- 1 mole of any substance = ***6.022 x 10^{23}*** particles.

A mole is a number of particles

- 1 mol H_2O = 6.022 x 10^{23} molecules H_2O
- 1 mol NaCl = 6.022 x 10^{23} formula units NaCl
- 1 mol Cu = 6.022 x 10^{23} atoms Cu
- 1mol people = 6.022 x 10^{23} people
- Again… 1 mol anything = 6.022 x 10^{23} particles
- **Moles are just a number of particles!**

The Mole and the Elements

- The *average atomic mass* represents the numbers of *grams* of an element equal to *1 mole* of that element.
- 1 mol C = 6.022 x 10^{23} atoms C
- 1 mol C = 12.01 g C
- 6.022 x 10^{23} atoms C = 12.01 g C

- 1 mol Ca = 6.022 x 10^{23} atoms Ca
- 1 mol Ca = 40.08 g Ca
- 6.022 x 10^{23} atoms Ca = 40.08 g Ca
- While 1 mol C = 1 mol Ca (both = 6.022 x 10^{23}), the mass of C *does not equal* the mass of Ca.

Converting between moles and grams

- The most important part of the mole concept is that it relates grams, an experimentally determinable amount of a substance to theoretical a number of particles, moles.
- **Moles are a number of particles!**
- atomic mass of elements is measured in amu, which is the same thing as grams/mole
- Therefore 1.008 g of H = 1 mole of H
- 22.99 g Na = 1 mole Na

Example

- How many moles are in 24 g of Cu
- $\frac{24 \text{ g Cu}}{} \left| \frac{1 \text{mole Cu}}{63.55 \text{ g Cu}} \right.$ = 0.3776613322 mol Cu

0.38 mol Cu (2 sig figs)

How many atoms of copper is this?

$.3776613322 \text{ mol Cu} \left| \frac{6.022 \times 10^{23} \text{ particles}}{1 \text{ mole}} \right.$

$= 2.3 \times 10^{23}$ atoms of Cu

Questions

- How many grams are 2.7 mol of iron?
- How many moles are 170 g of silver?
- How many atoms are 1.7 mol of tin?
- How many grams are 1.2×10^{24} atoms of magnesium?