Chapter 4: Calculations and the Chemical Equation

Section 4.1: The Mole Concept and Atoms

Atomic mass unit

- 1 amu = 1.661×10^{-24} g
- (this is roughly equal to the mass of ONE proton)

- Because the mass of one amu is so small, chemists deal with a much larger number of atoms while working with chemicals

Mole

- One mole is defined as 6.022×10^{23}.
- This refers to one mole of anything, eggs, paperclips, atoms. One mole of anything is 6.022×10^{23} items. Much like one dozen of something is 12.
- This number, 6.022×10^{23} is called Avogadro's number, named after the scientist who conducted a series of experiments leading to the "mole concept".

The mole concept

- The mole and the amu are related. For atoms, the atomic mass of an element corresponds to the average mass of a single atom in amu

And

- The mass of a mole of atoms in grams.

For example:

- The atomic mass of oxygen is 16.00 amu.

And

- One mole of oxygen atoms (6.022×10^{23} oxygen atoms) has a mass of 16.00 grams

Another example

- The atomic mass of iron (Fe) is 55.85 amu.

And

- One mole of iron atoms (6.022×10^{23} oxygen atoms) has a mass of 55.85 grams

And yet another example

- The atomic mass of radium (Ra) is 226 amu.

And

- One mole of radium atoms (6.022×10^{23} radium atoms) has a mass of 226 grams

Note

- One mole of atoms of any element contains 6.022×10^{23} atoms, regardless of the type of element.
- The mass of one mole of an element depends on what that element is, and is equal to the atom mass of that element in grams.

Converting moles to atoms

- How many atoms are in 4 moles of H?

4 moles H X 6.022 X 10^{23} atoms/mole = 24.088 X 10^{23} atoms of hydrogen or 2.409 X 10^{24} atoms

- In this case you multiply the number of moles X the number of atoms in each mole.

Converting atoms to moles

- Calculate the number of moles of copper represented by 3.26×10^{24} atoms.

$3.26 \times 10^{24} = 32.6 \times 10^{23}$ (ok, I did this step to make the math easier.)

$32.6 \times 10^{23} / 6.022 \times 10^{23} = 5.413 \times 10^{23}$ moles of copper.

- In this case, to convert atoms to moles, I divide the number of atoms by the number of atoms in one mol (by 6.022×10^{23})

Converting moles of a substance to mass in grams.

- What is the mass in grams of 5.6 mol of Neon?
- The mass of one mole of Ne is the same as the atomic mass in g (20.18 g)
- 5.6 mol X 20.18 g/mol = 100.9 g of Ne

Converting grams to numbers of atoms.

- How many atoms would be in a gold ring that weighs 25 g?
- First, find the number of moles of Gold in 25 g. Gold has an atomic mass of 107.9.
- So, 25 g / 107.9 g/mol = 0.2317 mol of gold are in the ring.
- Next, 0.2317 mol X (6.022×10^{23}) atoms/mol = 1.395×10^{23} atoms

When dealing with molecules. . .

- Like O_2 or H_2 , double the number of atoms, because there are 2 atoms per molecule.
- Remember, one mole of something is 6.022 X 10^{23} of whatever it is. If it is molecules, it's 6.022 X 10^{23} of them. If it is atoms, it's 6.022 x10^{23} atoms.
- If there are 2 atoms per molecule you need to double the number of moles.
- 2 X (6.022 X 10^{23}) = 12.044 X 10^{23} or 1.204 X 10^{24}

Formula weight vs Molecular Weight

- The sum of all of the atomic weights in the compound in an ionic compound it's the formula weight. In a covalent compound it's the molecular weight. These are BOTH usually referred to as the MOLAR MASS for that compound
- Each compound has its own, unique molar mass.

Molar mass (example)

What is the molar mass of magnesium chloride ($MgCl_2$) ?

- 24.3050 + 35.453(2) =
- 95.211 g/mol

- What is the molar mass of iron(III) sulfate $Fe_2(SO_4)_3$?
- 55.845(3) + 28.0855(3) + 15.9994(12) =
- 443.784 g/mol