Chapter 4: Calculations and the Chemical Equation

Section 4.1: The Mole Concept and Atoms
Atomic mass unit

1 amu = 1.661 \times 10^{-24} \text{ 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
One mole is defined as $6.022 \times 10^{23}$.

This refers to one mole of anything, eggs, paperclips, atoms. One mole of anything is $6.022 \times 10^{23}$ items. Much like one dozen of something is 12.

This number, $6.022 \times 10^{23}$ 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 X 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 \times 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 \((6.022 \times 10^{23}\) radium atoms\) has a mass of 226 grams
Note

One mole of atoms of any element contains $6.022 \times 10^{23}$ 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 \times 6.022 \times 10^{23} \text{ atoms/mole} = 24.088 \times 10^{23} \text{ atoms of hydrogen or } 2.409 \times 10^{24} \text{ atoms}

In this case you multiply the number of moles \times \text{ the number of atoms in each mole.}
Converting atoms to moles

Calculate the number of moles of copper represented by $3.26 \times 10^{24}$ 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 $6.022 \times 10^{23}$)
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, \( \frac{25\, \text{g}}{107.9\, \text{g/mol}} = 0.2317\, \text{mol} \) of gold are in the ring.

Next, \( 0.2317\, \text{mol} \times (6.022 \times 10^{23})\, \text{atoms/mol} = 1.395 \times 10^{23} \, \text{atoms} \)
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 \(\times\) \(10^{23}\) of whatever it is. If it is molecules, it’s 6.022 \(\times\) \(10^{23}\) of them. If it is atoms, it’s 6.022 \(\times\) \(10^{23}\) atoms.

- If there are 2 atoms per molecule you need to double the number of moles.

\[2 \times (6.022 \times 10^{23}) = 12.044 \times 10^{23} \text{ or } 1.204 \times 10^{24}\]
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.
What is the molar mass of magnesium chloride (MgCl$_2$)?

\[ 24.3050 + 35.453(2) = 95.211 \text{ g/mol} \]

What is the molar mass of iron(III) sulfate Fe$_2$(SO$_4$)$_3$?

\[ 55.845(3) + 28.0855(3) + 15.9994(12) = 443.784 \text{ g/mol} \]