The Mole

Chapter 3

The Mole

- A mole of *anything* is **6.02214 x 10^{23}** of that thing.
- In Chemistry, we work with very small particles, so we must work with a very **large** quantity of them.
- The mole is a convenient number to count a large quantity of particles.
- We can talk about a mole of anything, but we usually use it to talk about **atoms, molecules, ions,** and **formula units** – *Matter at the particle level.*

6.02214 x 10^{23} is also called Avogadro's number.

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Mole / Dozen Analogy

- Like the mole, a dozen of something is a convenient way to talk about the number of items we tend to buy in those quantities:

  1 dozen donuts = 12 donuts

  3 dozen eggs = 36 eggs

- The mole and the dozen make it easier to talk about large quantities.

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The mole and counting particles

- We can use Avogadro's number to convert between particles and moles:

  1 mole = 6.02214 x 10^{23} particles

- The conversion factors are:

$$\frac{6.022 \times 10^{23}\ \text{particles}}{1\ \text{mol}} \quad \text{or} \quad \frac{1\ \text{mol}}{6.022 \times 10^{23}\ \text{particles}}$$

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Mole – Particle Conversions

1) Convert 6.78 x 10^{24} atoms of argon to moles of argon.

2) Convert 0.881 moles of water to molecules of H_2O.

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Dimensional Analysis:

- Dimensional analysis problems use a series of ratios (conversion factors) to convert one unit to another.
- Dimensional analysis is a means of solving chemical problems in which the units are used to set up the problem.

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Steps in dimensional analysis

1) Identify the conversion to be performed:

   GIVEN UNITS → DESIRED UNITS

2) Setup a Dimensional Analysis table.

3) Insert conversion factors to eliminate unwanted units and introduce the desired units.

4) Compute.

***Example**:* Convert 68.4 centimeters to feet.

Note: The dimensional analysis table is identical to multiplying by fractions or ratios.

Atomic / Molar Masses

- We express the masses of individual atoms and molecules in **atomic mass units (amu).**
- One ***amu*** is defined as $^{1}/_{12}$ *the mass of an atom of the isotope carbon-12*.
  - An atom of Carbon-12 contains 6 protons and 6 neutrons in its nucleus (and 6 electrons in its electron cloud).

1 amu ≈ mass of 1 p^+ ≈ mass 1 n^0 ≈ mass of 1800 e^-

- However, we rarely work with small numbers of atoms or molecules. We usually work on the scale of

moles!

Atomic / Molar Masses

- Avogadro's number relates the ***atomic mass unit*** and the ***gram***:

  6.022×10^{23} amu = 1.000 g *(measured)*

- Therefore: **1 amu = 1 $^{g}/_{mol}$** *(exact)*
- An atom of Carbon-12 has an atomic mass of *exactly* (by definition) 12 amu or a ***molar mass*** of 12 g/mol.
  - 6.02214×10^{23} Carbon-12 atoms will have a mass of 12.0000 g.
- The **molar mass** of an element is its average atomic mass from the periodic table expressed in units of g/mol.

More Mole Conversions

1) What is the mass of 3.11 mol of nickel atoms?
2) What is the mass of 3.5×10^{22} atoms of gold?
3) How many formula units is 335 mg of magnesium chloride ($MgCl_2$)?
4) How many atoms are in 1.000 gram of xenon?
5) What is the mass of a single sodium-23 atom in grams? The isotopic mass of Na-23 is 22.99 amu.