

The Mole

The **mole**, commonly abbreviated *mol*, is the metric unit used to measure the amount of a substance. It is defined as the number of representative particles, carbon atoms, in exactly 12 g of carbon-12.

Through years of experimentation, it has been established that one mole of anything contains 6.02×10^{23} representative particles.

| Type of Substance | Representative Particle |
|--------------------|-------------------------|
| element | atoms |
| ion | ions |
| ionic compound | formula units |
| molecular compound | molecules |

The number 6.02×10^{23} is called **Avogadro's number**.

The mole is defined such that one mole of a natural element has a mass in grams that is equal to the element's atomic mass.

| Element | Mass of 1 atom | Mass of 1 mol |
|------------|----------------|---------------|
| Calcium-40 | 40 <i>amu</i> | 40 g |
| Carbon-12 | 12 <i>amu</i> | 12 g |
| Iron-56 | 56 <i>amu</i> | 56 g |

Molar Mass

The mass in grams of one mole of a substance is called the **molar mass** of the substance. It is usually expressed in grams per mole (*g/mol*).

For an element, the molar mass is numerically equal to the atomic mass. For a compound, the molar mass is equal to the formula mass of the compound (determined by adding up the masses of all the atoms in the compound).

Example 1

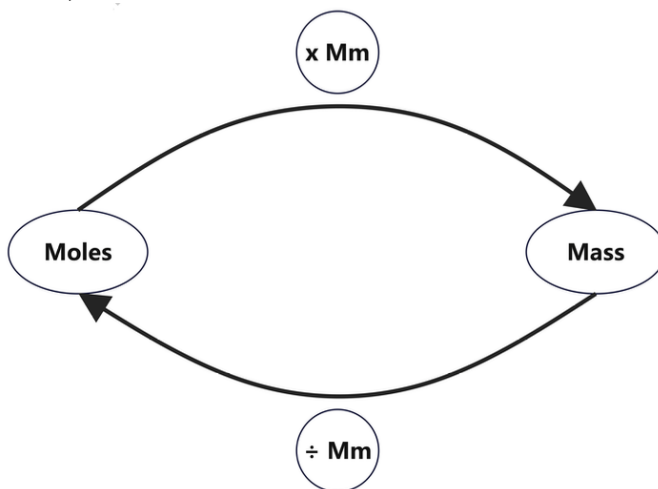
Determine the molar mass of methane (CH_4).

Mole Conversions

Because the mole measures both a mass and a number of particles it is the central unit in converting the amount of a substance from one type of measurement to another.

Converting Mass and Moles

To convert between the number of moles of a substance and its mass, you would either multiply or divide by the molar mass, as shown below:

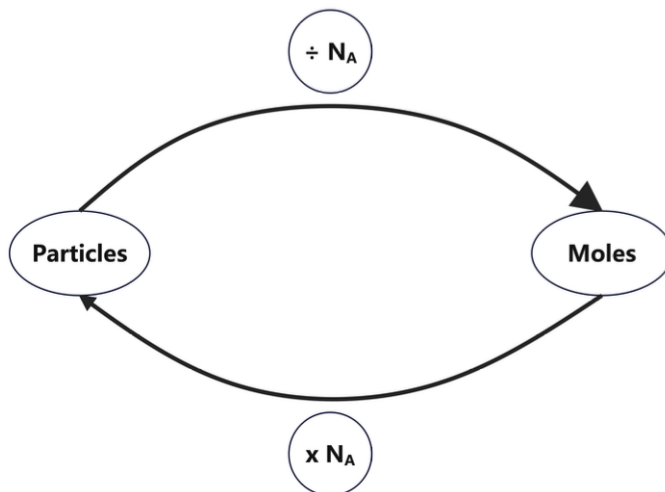


Example 2

To carry out a chemical reaction you need 3.20 moles of zinc nitrate ($Zn(NO_3)_2$). What is the mass of 3.20 moles of zinc nitrate?

Converting Particles and Moles

To convert between the number of moles of a substance and the number of representative particles, you would either multiply or divide by Avogadro's number, as shown below:

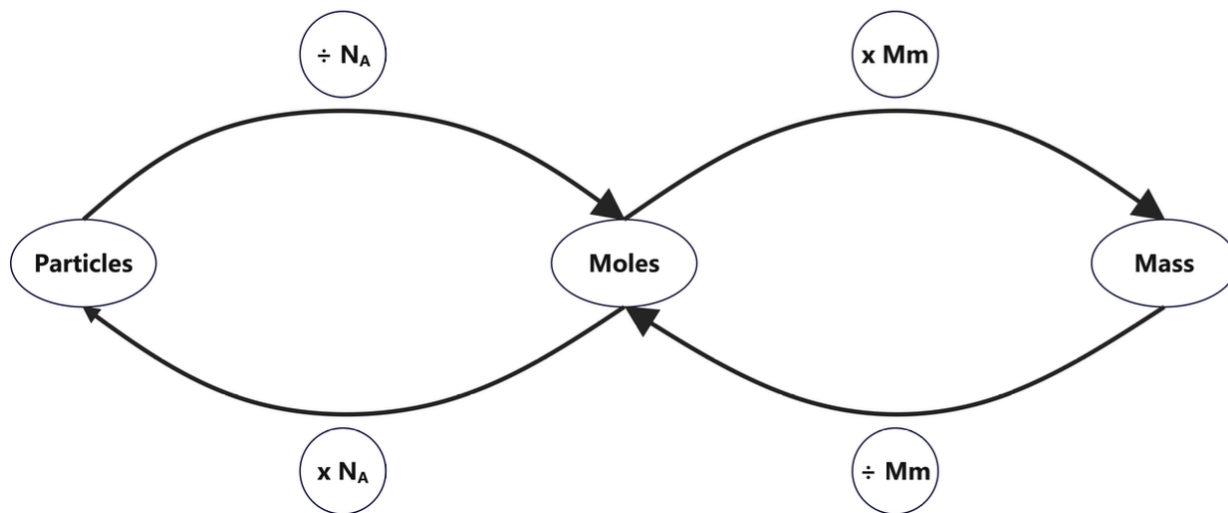


Example 3

A piece of marble contains 8.74×10^{23} formula units of calcium carbonate ($CaCO_3$). How many moles of calcium carbonate is that?

Multi-step Conversions

So far we have seen how to convert between moles and mass and between moles and particles. It is also possible to convert between mass and particles. To convert from mass to particles requires two steps, as illustrated below:



Example 4

You need 250 grams of table sugar, or sucrose ($C_{12}H_{22}O_{11}$), to bake a cake. How many sucrose molecules will be in the cake?

Moles and Conversions

1. Find the molar mass of carbon monoxide (CO).
2. Stomach acid is made up of hydrochloric acid (HCl). What is the molar mass of HCl ?
3. Find the mass of 0.65 mol of P_2O_5 .
4. A bottle of $NaNO_3$ contains 100 g of the compound. How many moles of $NaNO_3$ does it contain?
5. Determine the number of atoms in 0.36 mol of aluminum (Al).
6. How many moles of sodium carbonate (Na_2CO_3) contain 7.9×10^{24} formula units?
7. How many formula units of $NaHCO_3$ are in 1.8 g of sodium bicarbonate (baking soda)?
8. If you burned 4×10^{24} molecules of natural gas, or methane (CH_4), during a laboratory experiment, what mass of methane did you burn?