

5.3: Molar Mass



Figure 5.3.1 (Credit: Ben Mills (Wikimedia: Benjah-bmm27); Source: <http://commons.wikimedia.org/wiki/File:Potassium-dichromate-sample.jpg>(opens in new window); License: Public Domain)

When creating a solution, how do I know how much of each substance to put in?

I want to make a solution that contains 1.8 moles of potassium dichromate. You do not have a balance calibrated in moles, but you do have one calibrated in grams. If you know the relationship between moles and the number of grams in a mole, you can use your balance to measure out the needed amount of material.

Molar Mass

Molar mass is defined as the mass of one mole of representative particles of a substance. By looking at a periodic table, we can conclude that the molar mass of lithium is 6.94 g the molar mass of zinc is 65.38 g and the molar mass of gold is 196.97 g Each of these quantities contains 6.02×10^{23} atoms of that particular element. The units for molar mass are grams per mole, or g/mol.

Molar Masses of Compounds

The molecular formula of the compound carbon dioxide is CO_2 . One molecule of carbon dioxide consists of 1 atom of carbon and 2 atoms of oxygen. We can calculate the mass of one molecule of carbon dioxide by adding together the masses of 1 atom of carbon and 2 atoms of oxygen:

$$12.01 \text{ amu} + 2 (16.00 \text{ amu}) = 44.01 \text{ amu}$$

The **molecular mass** of a compound is the mass of one molecule of that compound. The molecular mass of carbon dioxide is 44.01 amu

The molar mass of any compound is the mass in grams of one mole of that compound. One mole of carbon dioxide molecules has a mass of 44.01 g while one mole of sodium sulfide formula units has a mass of 78.04 g The molar masses are 44.01 g/mol and 78.04 g/mol respectively. In both cases, that is the mass of 6.02×10^{23} representative particles. The representative particle of CO_2 is the molecule, while for Na_2S it is the formula unit.

5.3.1 Example : Molar Mass of a Compound

Calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, is used as a component in fertilizer. Determine the molar mass of calcium nitrate.

Solution

Step 1: List the known and unknown quantities and plan the problem.

Known

- Formula = $\text{Ca}(\text{NO}_3)_2$
- Molar mass Ca = 40.08 g/mol
- Molar mass N = 14.01 g/mol
- Molar mass O = 16.00 g/mol

Unknown

- molar mass $\text{Ca}(\text{NO}_3)_2$

First we need to analyze the formula. Since the Ca lacks a subscript, there is one Ca atom per formula unit. The 2 outside the parentheses means that there are two nitrate ions per formula unit and each nitrate ion consists of one nitrogen atom and three oxygen atoms per formula unit. Thus, 1 mol of calcium nitrate contains 1 mol of Ca atoms, 2 mol of N atoms, and 6 mol of O atoms.

Step 2: Calculate

Use the molar masses of each atom together with the number of atoms in the formula and add together.

$$1 \text{ mol Ca} \times \frac{40.08 \text{ g Ca}}{1 \text{ mol Ca}} = 40.08 \text{ g Ca}$$

$$2 \text{ mol N} \times \frac{14.01 \text{ g N}}{1 \text{ mol N}} = 28.02 \text{ g N}$$

$$6 \text{ mol O} \times \frac{16.00 \text{ g O}}{1 \text{ mol O}} = 96.00 \text{ g O}$$

$$\text{Molar mass of Ca(NO}_3)_2 = 40.08 \text{ g} + 28.02 \text{ g} + 96.00 \text{ g} = 164.10 \text{ g/mol}$$



Summary

- Calculations are described for the determination of molar mass of an atom or a compound.

Review

- What is the molar mass of Pb?
- Where do you find the molar mass of an element?
- How many moles of Cl are in one mole of the CaCl_2 ?
- How many moles of H are in one mole of the compound $(\text{NH}_4)_3\text{PO}_4$?
- Calculate the molar mass of CaCl_2 .

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