

6.5: Chemical Formulas as Conversion Factors

Learning Objectives

- Use chemical formulas as conversion factors.

Figure 6.5.1 shows that we need 2 hydrogen atoms and 1 oxygen atom to make one water molecule. If we want to make two water molecules, we will need 4 hydrogen atoms and 2 oxygen atoms. If we want to make five molecules of water, we need 10 hydrogen atoms and 5 oxygen atoms. The ratio of atoms we will need to make any number of water molecules is the same: 2 hydrogen atoms to 1 oxygen atom.

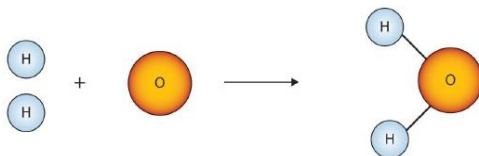


Figure 6.5.1 Water Molecules. The ratio of hydrogen atoms to oxygen atoms used to make water molecules is always 2:1, no matter how many water molecules are being made.

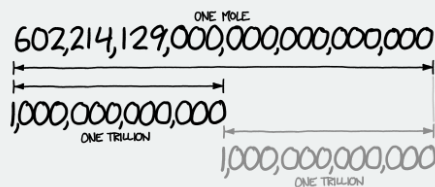
Using formulas to indicate how many atoms of each element we have in a substance, we can relate the number of moles of molecules to the number of moles of atoms. For example, in 1 mol of water (H_2O) we can construct the relationships given in (Table 6.5.1).

Table 6.5.1: Molecular Relationships for Water

1 Molecule of H_2O Has	1 Mol of H_2O Has	Molecular Relationships
2 H atoms	2 mol of H atoms	$\frac{2 \text{ mol H atoms}}{1 \text{ mol H}_2\text{O molecules}}$ or $\frac{1 \text{ mol H}_2\text{O molecules}}{2 \text{ mol H atoms}}$
1 O atom	1 mol of O atoms	$\frac{1 \text{ mol O atoms}}{1 \text{ mol H}_2\text{O molecules}}$ or $\frac{1 \text{ mol H}_2\text{O molecules}}{1 \text{ mol O atoms}}$

The Mole is big

A mole represents a very large number! The number 602,214,129,000,000,000,000,000 looks about twice as long as a trillion, which means it's about a trillion trillion.



(CC BY-SA NC; [what if?](http://what-if.xkcd.com) [what-if.xkcd.com]).

A trillion trillion kilograms is how much a planet weighs. If 1 mol of quarters were stacked in a column, it could stretch back and forth between Earth and the sun 6.8 billion times.

Table 6.5.2: Molecular and Mass Relationships for Ethanol

1 Molecule of $\text{C}_2\text{H}_6\text{O}$ Has	1 Mol of $\text{C}_2\text{H}_6\text{O}$ Has	Molecular and Mass Relationships
2 C atoms	2 mol of C atoms	$\frac{2 \text{ mol C atoms}}{1 \text{ mol C}_2\text{H}_6\text{O molecules}}$ or $\frac{1 \text{ mol C}_2\text{H}_6\text{O molecules}}{2 \text{ mol C atoms}}$
6 H atoms	6 mol of H atoms	$\frac{6 \text{ mol H atoms}}{1 \text{ mol C}_2\text{H}_6\text{O molecules}}$ or $\frac{1 \text{ mol C}_2\text{H}_6\text{O molecules}}{6 \text{ mol H atoms}}$

1 Molecule of C_2H_6O Has	1 Mol of C_2H_6O Has	Molecular and Mass Relationships
1 O atom	1 mol of O atoms	$\frac{1 \text{ mol O atoms}}{1 \text{ mol } C_2H_6O \text{ molecules}}$ or $\frac{1 \text{ mol } C_2H_6O \text{ molecules}}{1 \text{ mol } C_2H_6O \text{ molecules}}$
2 (12.01 amu) C 24.02 amu C	2 (12.01 g) C 24.02 g C	$\frac{1 \text{ mol O atoms}}{24.02 \text{ g C}}$ or $\frac{1 \text{ mol } C_2H_6O \text{ molecules}}{24.02 \text{ g C}}$
6 (1.008 amu) H 6.048 amu H	6 (1.008 g) H 6.048 g H	$\frac{6.048 \text{ g H}}{1 \text{ mol } C_2H_6O \text{ molecules}}$ or $\frac{1 \text{ mol } C_2H_6O \text{ molecules}}{6.048 \text{ g H}}$
1 (16.00 amu) O 16.00 amu O	1 (16.00 g) O 16.00 g O	$\frac{16.00 \text{ g O}}{1 \text{ mol } C_2H_6O \text{ molecules}}$ or $\frac{1 \text{ mol } C_2H_6O \text{ molecules}}{16.00 \text{ g O}}$


The following example illustrates how we can use the relationships in Table 6.5.2 as conversion factors.

✓ Example 6.5.1: Ethanol

If a sample consists of 2.5 mol of ethanol (C_2H_6O), how many moles of carbon atoms does it have?

Solution

Solutions to Example 6.5.1

Steps for Problem Solving	If a sample consists of 2.5 mol of ethanol (C_2H_6O), how many moles of carbon atoms does it have?
Identify the "given" information and what the problem is asking you to "find."	Given: 2.5 mol C_2H_6O Find: mol C atoms
List other known quantities.	1 mol C_2H_6O = 2 mol C
Prepare a concept map and use the proper conversion factor.	 $\frac{2 \text{ mol C}}{1 \text{ mol } C_2H_6O}$
Cancel units and calculate.	Note how the unit $\text{mol } C_2H_6O \text{ molecules}$ cancels algebraically. $2.5 \text{ mol } C_2H_6O \text{ molecules} \times \frac{2 \text{ mol C atoms}}{1 \text{ mol } C_2H_6O \text{ molecules}} = 5.0 \text{ mol C atoms}$
Think about your result.	There are twice as many C atoms in one C_2H_6O molecule, so the final amount should be double.

? Exercise 6.5.1

If a sample contains 6.75 mol of Na_2SO_4 , how many moles of sodium atoms, sulfur atoms, and oxygen atoms does it have?

Answer

13.5 mol Na atoms, 6.75 mol S atoms, and 27.0 mol O atoms

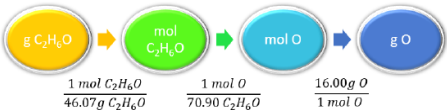
The fact that 1 mol equals 6.022×10^{23} items can also be used as a conversion factor.

✓ Example 6.5.2: Oxygen Mass

Determine the mass of Oxygen in 75.0g of C_2H_6O .

Solution

Solutions to Example 6.5.2

Steps for Problem Solving	Determine the mass of Oxygen in 75.0g of C_2H_6O
Identify the "given" information and what the problem is asking you to "find."	Given: 75.0g C_2H_6O Find: g O
List other known quantities.	1 mol O = 16.0g O 1 mol C_2H_6O = 1 mol O 1 mol C_2H_6O = 46.07g C_2H_6O
Prepare a concept map and use the proper conversion factor.	 <p>The conversion factors are 1 mol C_2H_6O over 46.07 g C_2H_6O, 1 mol O over 1 mol C_2H_6O, and 16.00 g O over 1 mole O.</p>
Cancel units and calculate.	$75.0 \text{ g } C_2H_6O \times \frac{1 \text{ mol } C_2H_6O}{46.07 \text{ g } C_2H_6O} \times \frac{1 \text{ mol O}}{1 \text{ mol } C_2H_6O} \times \frac{16.00 \text{ g O}}{1 \text{ mol O}} = 26.0 \text{ g O}$
Think about your result.	

? Exercise 6.5.2

- How many molecules are present in 16.02 mol of C_4H_{10} ? How many C atoms are in 16.02 mol?
- How many moles of each type of atom are in 2.58 mol of Na_2SO_4 ?

Answer a:

9.647×10^{24} C_4H_{10} molecules and 3.859×10^{25} C atoms

Answer b:

5.16 mol Na atoms, 2.58 mol S atoms, and 10.3 mol O atoms

Summary

In any given formula, the ratio of the number of moles of molecules (or formula units) to the number of moles of atoms can be used as a conversion factor.

6.5: Chemical Formulas as Conversion Factors is shared under a CK-12 license and was authored, remixed, and/or curated by Marisa Alviar-Agnew & Henry Agnew.