8.3: Molecular Mass and Formula Mass

Learning Objectives

- Define formula mass and molecular mass.
- To determine the formula mass of an ionic compound or molecular mass of a molecular compound.

Why is knowledge of composition important? Everything in nature is either chemically or physically combined with other substances. To find the amount of a material in a sample, you need to know what fraction of the sample it is. Some simple applications of composition are: the amount of sodium in sodium chloride for a diet, the amount of iron in iron ore for steel production, the amount of hydrogen in water for hydrogen fuel, and the amount of chlorine in freon to estimate ozone depletion.

Figure 8.3.1: How much sodium is in this spoonful of salt? (via Flickr; Gianni pepenera).

Molecular Mass and Formula Mass

The composition of a compound may be determined from its chemical formula and the atomic masses of the elements that make up the compound. The mass of a molecule is called its **molecular mass**. The molecular mass is calculated summing the masses of all the atoms shown in the chemical formula.

Ionic compounds are not comprised of discrete molecules, but rather, ions. The smallest unit of an ionic compound that retains the identity of an ionic compound is called a **formula unit**. The mass of a formula unit is called its **formula mass**. The formula mass is calculated summing the masses of all the atoms shown in the chemical formula. In other words, the molecular mass and formula mass are both calculated in an identical manner, by summing the masses of all the atoms shown in the chemical formula.

As you may recall, the periodic table shows the average mass of the atoms for each element. We called this mass the atomic mass. The atomic mass of sodium is 22.99 amu and the atomic mass of chlorine is 35.45 amu.

11
Na
22.99

17
Cl
35.45

Since NaCl is an ionic compound, we could calculate its formula mass. This formula mass is the sum of the atomic masses of one sodium atom and one chlorine atom, which we find from the periodic table:

1 Na: 22.99 amu

1 Cl: +35.45 amu

Total: 58.44 amu

In other words, the formula mass of NaCl is 58.44 amu. We may also say that one formula unit of NaCl has a mass of 58.44 amu.

✅ Example 8.3.1

Calculate the molecular mass or formula mass for each compound. (Periodic Table)

A. $C_{12}H_{22}O_{11}$
B. $Ca(NO_3)_2$

Solution

	$C_{12}H_{22}O_{11}$	$Ca(NO_3)_2$
1. Determine how many atoms of each element are present in the compound. Multiply the number of atoms of each element by its atomic mass.	12 C = 12(12.01) = 144.1 amu 22 H = 22(1.008) = 22.18 amu 11 O = 11(16.00) = 176.0 amu	1 Ca = 1(40.08) = 40.08 amu 2 N = 2(14.01) = 28.02 amu 6 O = 6(16.00) = 96.00 amu
2. Sum the masses to find the molecular mass or formula mass.	molecular mass = 342.3 amu	formula mass = 164.10 amu
3. Explanation.	It is called a molecular mass since $C_{12}H_{22}O_{11}$ is a molecular compound.	It is called a formula mass since $Ca(NO_3)_2$ is an ionic compound.
4. Interpretation.	One molecule of $C_{12}H_{22}O_{11}$ has a mass of 342.3 amu.	One formula unit of $Ca(NO_3)_2$ has a mass of 164.10 amu.

? ✏️ Exercise 8.3.1

Calculate the molecular mass or formula mass for each compound. (Periodic Table)

A. TiO_2
B. $C_6H_{12}O_6$
C. $Fe_3(PO_4)_2$

Answer A

The formula mass is 79.90 amu.

Answer B

The molecular mass is 180.16 amu.

Answer C

The formula mass is 357.5 amu.

Summary

- Formula masses of ionic compounds and molecular masses of molecular compounds can be determined from the masses of the atoms in their formulas.