Chapter 6 Chemical Composition

6.1 Atoms and Moles

Key Terms

atomic mass unit average atomic mass mole
Avogadro's number

Summary

A large collection of individual objects can be counted by weighing if the average mass of the objects is known. The principle also applies to atoms.

If the average mass of the atoms of an element is known, the number of atoms in any sample of that element can be determined by weighing the sample. The opposite calculation works as well. If we know the number of atoms in a sample, we can calculate the sample's mass.

Because atoms are so tiny, the units of grams and kilograms are much too large to be convenient. Scientists have defined a much smaller unit of mass to describe the mass of a single atom. This unit is called the *atomic mass unit,* or amu. One amu equals 1.66×10^{-24} g. Every element has an *average atomic mass* in amu.

Two samples whose masses in grams have the same ratio (relation to each other) as the ratio of their average atomic masses in amu always contain the same number of atoms. *Avogadro's number* is 6.022×10^{23}. A *mole* is defined as a unit of measure equal to the number of carbon atoms in 12.01 g of carbon, which equals 6.022×10^{23}.

6.2 Molar Mass and Percent Composition

Key Terms

molar mass mass percent

Summary

One mole of an element has a mass equal to the element's atomic mass expressed in grams. The *molar mass* of any compound is the mass (in grams) of 1 mol of the compound and is the sum of the masses of the atoms that make it up.

Percent composition consists of the mass percent of each element in a compound. *Mass percent* equals the mass of a given element in 1 mol of compound divided by the mass of 1 mol of that compound multiplied by 100%. To calculate the mass percent of an element in a compound, first we find the individual mass of that element by dividing the mass of that element contained in 1 mol of the compound by the total mass of 1 mol of the compound. Then, to convert the mass fraction to the mass percent, multiply by 100%.

6.3 Formulas of Compounds

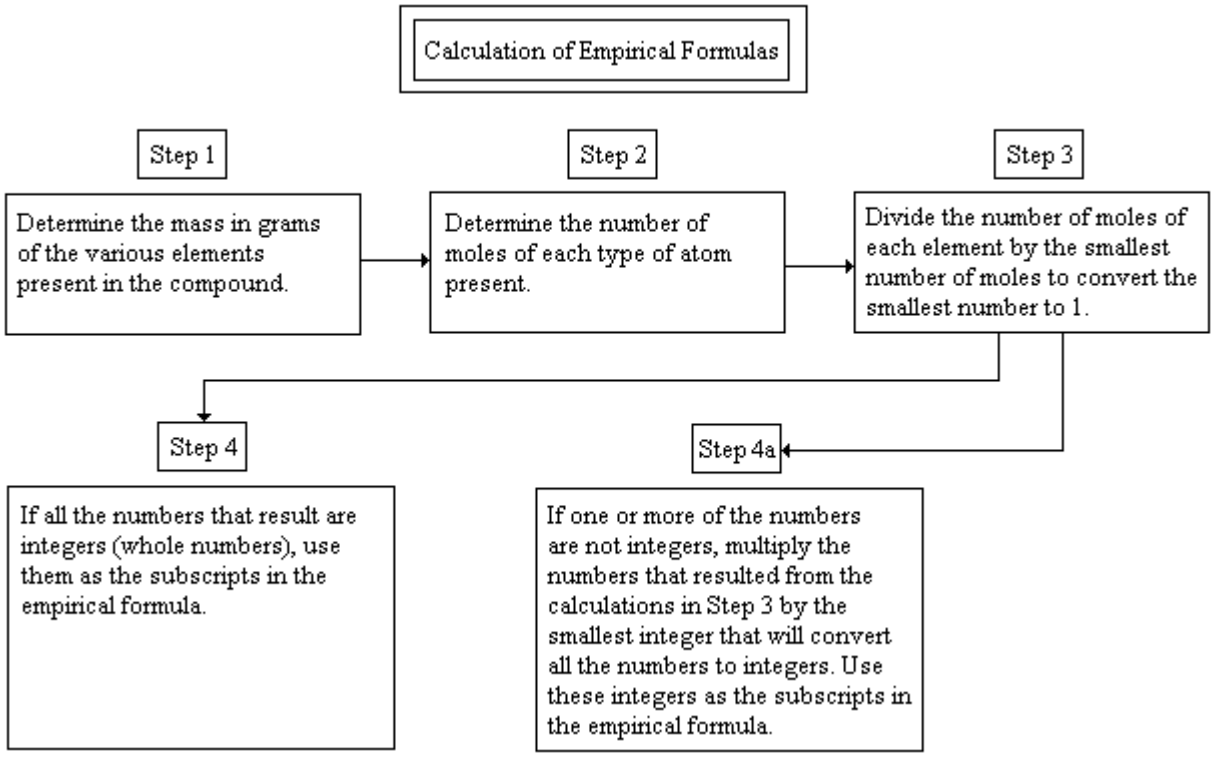
Key Terms

empirical formula molecular formula

Summary

When a chemical reaction gives an unknown product, a chemist can determine what compound has been formed by figuring out which elements and how many atoms of each element form the compound. However, when we break a compound down into its separate elements and then count the atoms present, we learn only the numbers of atoms relative to one another. The formula that expresses this ratio is called the *empirical formula.* The formula of the compound that tells how many atoms of each element actually are present in each of the compound's molecules is called the *molecular formula.* The molecular formula is always a whole-number multiple of the empirical formula.

There are four basic steps in the calculation of empirical formulas.



To determine the molecular formula of a compound, we compare the empirical formula mass to the molar mass. The empirical formula mass is the mass of 1 mol of an empirical formula unit. The unknown molecular formula is equal to the known empirical formula multiplied by an unknown whole number. To find the value of the unknown whole number, we divide the molar mass of the molecular formula by the empirical formula mass. This calculation tells us

the number of empirical formula masses that are present in one molar mass. The subscripts in the empirical formula then are multiplied by that number to get the molecular formula.

Additional Active Reading Questions

1. What factor must be known in order to count the units in a sample by weighing it?

2. What is an atomic mass unit? What is its value?

3. What are the two names for the number 6.022×10^{23}?

4. What is the molar mass of a compound? How is it determined?

5. Which type of formula describes the numbers of atoms in a compound relative to one another?

6. When the molar mass of a compound which has the empirical unit, C_5H_4, is divided by the empirical formula mass, the result is 2. What is the compound's molecular formula?