

Empirical and Molecular Formulas

The *empirical formula* of a compound gives the *simplest whole number ratio* of different types of atoms in the compound. *All* salt formulas are empirical formulas. On the other hand, the molecular formula of a compound may or may not be the same as its empirical formula. For example, the molecular formula of butane is C_4H_{10} while its empirical formula is C_2H_5 . The *molecular formula* gives the true number of each kind of atom in a molecule.

Empirical formulas may be easily determined from experimental data.

- Usually you must first determine how many grams of each type of atom are in the compound. If percent composition data is given, assume that you have 100.0 g of the compound; then the number of grams of each element is equal to the percentage for that element.
- The next task is convert the *grams* of each element to *moles* of the element. Be sure to keep at least three significant figures in your answers.
- The final step is to *write the molar amounts of each element as subscripts* in the formula. Then divide all molar subscripts by the *smallest* value in the set. At this point, the subscripts may all be very close to whole numbers; if so, you are finished. If one (or more) of the subscripts is *not* close to a whole number, multiply *all* molar subscripts by the simple factor which makes all subscripts whole numbers.

Once the empirical formula is determined, the molecular formula is easily found *if the molar mass (molecular weight) of the molecule is also known*. You first calculate the molar mass of the empirical formula. Then you divide the molar mass of the molecule by the molar mass of the empirical formula. The division should give a simple whole number. That number is the factor by which all subscripts in the empirical formula must be multiplied to obtain the molecular formula.

Exercises

1. The molecular formula of the antifreeze ethylene glycol is $C_2H_6O_2$. What is the empirical formula?
2. A well-known reagent in analytical chemistry, dimethylglyoxime, has the empirical formula C_2H_4NO . If its molar mass is 116.1 g/mol, what is the molecular formula of the compound?
3. Nitrogen and oxygen form an extensive series of oxides with the general formula N_xO_y . One of them is a blue solid that comes apart, reversibly, in the gas phase. It contains 36.84% N. What is the empirical formula of this oxide?
4. A sample of indium chloride weighing 0.5000 g is found to contain 0.2404 g of chlorine. What is the empirical formula of the indium compound?