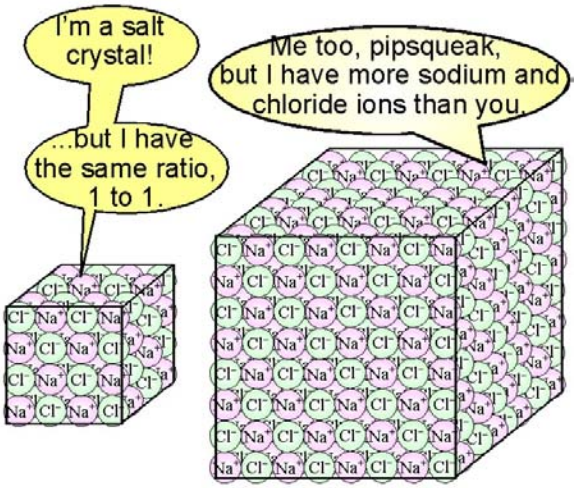
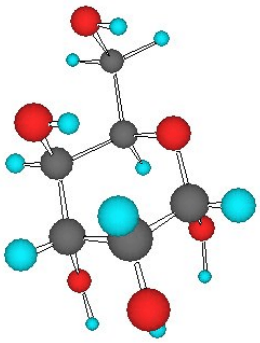
Empirical Formulas



The chemical formula for a molecular compound shows the number and type of atoms present in a molecule. Ionic crystals are a collections of ions. The chemical formula for an ionic compound shows the ratio ions in the compound. The ratio of ions in the formula for an ionic compound is always in lowest terms. A chemical formula in which the ratio of the elements are in lowest terms is called an empirical formula. For example, the formula for table salt, sodium chloride, is NaCl even though a salt crystal may have millions of ions and millions of ionic bonds. A glucose,



molecule ($C_6H_{12}O_6$) such as the one pictured to the left, on the other hand, has exactly six carbon atoms, twelve hydrogen atoms, and six oxygen atoms per molecule. The molecular formula for glucose is not an empirical formula. All the subscripts are divisible by six. When the subscripts are divided by six, the empirical formula for glucose, CH_2O, is obtained. Some molecular formulas, such as the one for carbon dioxide, CO_2, are already empirical formulas without being reduced.

There are two skills you need to learn in order to work with empirical formulas. They are finding the empirical formula from the molecular formula and Finding the molecular formula from the empirical formula and the molecular mass:

- to find the empirical formula from the molecular formula

  divide all the subscripts by the greatest common factor

Determine the empirical formula, for each of the following molecular formulas.

1. C_8H_{18} . . . . . _____
2. H_2O_2 . . . . . _____
3. Hg_2Cl_2 . . . . . _____
4. $C_3H_6O_3$ . . . . . _____
5. $Na_2C_2O_4$ . . . . _____
6. H_2O . . . . . _____
7. C_4H_8 . . . . . _____
8. C_4H_6 . . . . . _____
9. C_7H_{12} . . . . . _____
10. CH_3COOH . . _____

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- to find the molecular formula from the empirical formula and the molecular mass.

Step 1: Determine the empirical formula mass.
Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple..
Step 3: Multiply the empirical formula by the by the multiple to find the molecular formula

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Sample Problem

A compound with an empirical formula of CH_2O has a molecular mass of 90 amu. What is its molecular formula?

Step 1: Determine the empirical formula mass.

CH_2O

C = 12 × 1 = 12
H = 1 × 2 = 2
O = 16 × 1 = 16
30

Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple.

$$\frac{90}{30} = 3$$

Step 3: Multiply the empirical formula by the by the multiple to find the molecular formula

$[CH_2O] \times 3 = C_3H_6O_3$

Determine the molecular formula for each of the following:

11. Find the molecular formula for a compound with a mass of 78 amu and the empirical formula CH.

12. Find the molecular formula for a compound with a mass of 82 amu and the empirical formula C_3H_5.

13. Find the molecular formula for a compound with a mass of 90 amu and the empirical formula HCO_2.

14. Find the molecular formula for a compound with a mass of 112 amu and the empirical formula CH_2.

15. Find the molecular formula for a compound with a mass of 40 amu and the empirical formula C_3H_4.