The Mole Concept

Learning Target:
I can calculate empirical and molecular formulas.

Criteria for Success:
I can define empirical formula and molecular formula.
I can calculate empirical formula for a compound.
I can calculate molecular formula for a compound.

Empirical Formula
A. An _____ formula consists of the symbols for the _____ combined in a compound, with _____ showing the smallest whole-number mole ratio of the different atoms in the compound.

    1. For an _____ compound, the _____ _____ is usually the compound's empirical formula.

    2. For a _____ (molecular) compound, a _____ may not always represent the compound's empirical formula.

Molecular Formula
A. While the _____ formula represents the smallest whole number ratio of elements in a compound, the _____ formula is the actual formula of a compound and is a _____,n, multiple of the empirical formula.

$$n(empirical\ formula) = molecular\ formula$$

    1. The number represented by *x* is a _____ number multiple indicating the factor by which the subscripts in the _____formula must be multiplied to obtain the _____ formula. It is determined by relating the molar mass of a compound to the molar mass of its empirical formula.

$$n = \frac{molar\ mass}{empirical\ formula\ molar\ mass}$$

    2. For an _____ compound, the empirical and molecular formulas are typically the _____.

    3. For a _____ (molecular) compound, the empirical and molecular formula may or may _____ be the _____.

Tips for the Calculation of Empirical and Molecular Formula
A. When given percent composition of a compound, assume _____ of the compound. This will make determination of the _____ of each element easier.

B. Remember that the _____ represent the ratio of _____ of each element in a formula, therefore, if you are given masses you must convert to moles.

C. If the mole ratio is not an exact _____ number, but close to it (usually less than 0.1 mole), simply round to the nearest whole number.

D. If the mole ratio is not an exact _____ number, and NOT close to it (usually greater than 0.1 mole), you must multiply each amount in moles by a factor that will give you a _____ number ratio.

    1. Remember that the _____ 0.50, 0.33, 0.67, 0.25, 0.75, and 0.20 correspond to the _____ 1/2, 1/3, 2/3, 1/4, 3/4, and 1/5, respectively. You can use the denominator in these fractions as the factor to multiply your amounts in moles to achieve whole number ratios.

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Guided Practice

1. Qualitative analysis shows that a compound contains 32.28% sodium, 22.65% sulfur, and 44.99% oxygen. Find the empirical formula of this compound.

2. Analysis of a 10.150g sample of a compound known to contain only phosphorus and oxygen indicates a phosphorus content of 4.433g. What is the empirical formula of this compound?

3. The empirical formula of a compound of phosphorus and oxygen was found to be P_2O_5. Experimentation shows that the molar mass of this compound is 283.89g/mol. What is the compound's molecular formula?

4. A sample of a compound with a formula mass of 34.00amu is found to consist of 0.44g H and 6.92g O. Find its molecular formula.

Independent Practice

1. A compound is found to contain 63.52% iron and 36.48% sulfur. Find its empirical formula.

FeS

2. Analysis of 20.0g of a compound containing only calcium and bromine indicates that 4.00g of calcium are present. What is the empirical formula of the compound formed?

$CaBr_2$

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3. Find the empirical formula of a compound found to contain 26.56% potassium, 35.41% chromium, and the remainder oxygen.

$$K_2Cr_2O_7$$

4. A 60.00g sample of tetraethyl-lead, a gasoline additive, is found to contain 38.43g lead, 17.83g carbon, and 3.74g hydrogen. Find its empirical formula.

$$PbC_8H_{20}$$

5. The empirical formula for trichloroisocyanuric acid, the active ingredient in many types of bleach, is OCNCl. The molar mass of this compound is 232.41g/mol. What is the molecular formula of trichloroisocyanuric acid?

$$\frac{mm \; mlc}{mm \; emp} = 3 \qquad\qquad O_3C_3N_3Cl_3$$

6. Determine the molecular formula of a compound with an empirical formula of NH_2 and a formula mass of 32.06amu.

$$\frac{mm \; mlc}{mm \; emp} = 2 \qquad\qquad N_2H_4$$

7-11. In the laboratory, a sample of pure nickel was placed in a clean, dry, weighted crucible. The crucible was heated so that the nickel would react with the oxygen in the air. After the reaction appeared complete, the crucible was allowed to cool and the mass was determined. The crucible was reheated and allowed to cool. Its mass was then determined again to be certain that the reaction was complete. The following data were collected:

Data Table 1: Calculation of Empirical Formula of Nickel Oxide

Mass of crucible	30.02g
Mass of nickel and crucible	31.07g
Mass of nickel oxide and crucible	31.36g

7. What is the mass of the nickel? $31.07 - 30.02 = 1.05g$
8. What is the mass of the nickel oxide? $31.36 - 30.02 = 1.34g$
9. What is the mass of oxygen? $1.34 - 1.05 = .29g$
10. Based on your calculations, what is the empirical formula for the nickel oxide? NiO
11. If the molar mass of the compound is determined to be 74.692g, what is the molecular formula of the nickel oxide?

$$\frac{mm \; mlc}{mm \; Emp} = 1 \qquad\qquad NiO$$