

Chemical Quantities Outline

(Percent Composition & Empirical Formulas)

Percent Composition

- Percent composition is the percent by mass of each element in a compound
- Using the mass of the element you solve using the following formula:

$$\% \text{ by mass of element} = \frac{\text{mass of element}}{\text{mass of compound}} \times 100$$

When a 13.60g sample of a compound containing only magnesium and oxygen is broken down, 5.40g of oxygen and 8.20g of Mg are obtained. What is the percent composition of this compound?

Oxygen

$$\frac{5.40\text{g Oxygen}}{13.60\text{g Compound}} \times 100 = 39.7\% \text{ Oxygen}$$

magnesium

$$\frac{8.20\text{g Mg}}{13.60\text{g Compound}} \times 100 = 60.3\% \text{ Magnesium}$$

Percent Composition from a Chemical Formula

- Formula: $\% \text{ by mass of an element} = \frac{\text{molar mass of element}}{\text{molar mass of compound}} \times 100$

Propane (C_3H_8), the fuel commonly used in gas grills, is one of the compounds obtained from petroleum.

Calculate the percent composition of propane.

$$\text{C} \Rightarrow 3 \left(\frac{12.01\text{g}}{\text{mole}} \right) = 36.03\text{g/mole}$$

$$\text{C} \Rightarrow \frac{36.03\text{g/mole}}{44.11\text{g/mole}} \times 100 = 81.8\% \text{ C}$$

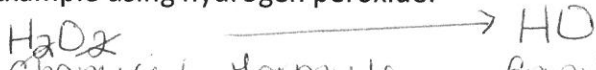
$$\text{H} = 8 \left(\frac{1.01\text{g}}{\text{mole}} \right) = 8.08\text{g/mole}$$

$$\text{H} \Rightarrow \frac{8.08\text{g/mole}}{44.11\text{g/mole}} \times 100 = 18.3\% \text{ H}$$

$$\text{Total Molar Mass} = 44.11\text{g/mole}$$

Empirical Formulas

- Empirical formulas are the lowest whole number ratio of the atoms or moles of elements in a compound
- May or may not be the same as the molecular formula
- Example using hydrogen peroxide:



Molecular Formulas

Chemical formula Empirical formula

- Either the same as the empirical formula or a simple whole number multiple of the empirical formula

- Some examples:

molecular formula	=	empirical formula
H ₂ O ₂	=	HO
C ₆ H ₁₂ O ₆	=	CH ₂ O
N ₂ O ₆	=	NO ₃
H ₂ O	=	H ₂ O
C ₂ H ₁₀ O ₂	=	CH ₅ O
N ₃ O ₂	=	N ₃ O ₂
P ₄ O ₁₀	=	P ₂ O ₅

The Percent Composition of a compound can be used to calculate the empirical formula of that compound.

5 steps:

1. Change % to grams
2. Convert mass to moles
3. Divide by smallest number of moles
4. If not whole numbers, multiply all by the smallest whole number that gives all whole numbers for answers
5. Write the whole numbers for step 4 as the subscripts for the elements in the empirical formula

A compound is analyzed and found to contain 25.9% nitrogen and 74.1% oxygen. What is the empirical formula?

$$N = 25.9\% = 25.9g$$

$$25.9g N \left(\frac{1 \text{ mol}}{14g N} \right) = \frac{1.85 \text{ mol } N}{1.85} = 1$$

$$O = 74.1\% = 74.1g$$

$$74.1g O \left(\frac{1 \text{ mol}}{16.00g} \right) = \frac{4.63 \text{ mol}}{1.85} = 2.5$$

$$2.5 \times 2 = 5$$

1x2 = 2 Empirical formula N₂O₅

Calculate the empirical formula for a compound that is 67.6% Hg, 10.8% S, and 21.6% O.

$$Hg = 67.6g$$

$$67.6g Hg \left(\frac{1 \text{ mol}}{200.59g Hg} \right) = \frac{0.337 \text{ mol}}{0.337} = 1$$

$$S = 10.8g$$

$$10.8g S \left(\frac{1 \text{ mol}}{32.06g S} \right) = \frac{0.337 \text{ mol}}{0.337} = 1$$

$$O = 21.6g$$

$$21.6g O \left(\frac{1 \text{ mol}}{16.00g O} \right) = \frac{1.35 \text{ mol}}{0.337} = 4$$

Empirical formula HgSO₄

Calculate the molecular formula of a compound whose molar mass is 60.0g/mol and empirical formula is CH₄N

$$C = 12.01 \frac{g}{mol}$$

$$H = 4(1.01g/mol) = 4.04 \frac{g}{mol}$$

$$N = 14.01 \frac{g}{mol}$$

Empirical formula mass

$$C = 12.01 \text{ g/mol}$$

$$H = 4.04 \text{ g/mol}$$

$$N = 14.01 \text{ g/mol}$$

$$\frac{30.06 \text{ g}}{\text{mol}}$$

Divide the molar mass
by empirical formula
mass

$$\frac{60.0 \text{ g/mol}}{30.0 \text{ g/mol}} = 2$$

Multiply the empirical formula
by this value to figure
out the molecular formula



Find the molecular formula of ethylene glycol, which is used as antifreeze. The molar mass is 62.0 g/mol, and the empirical formula is CH_3O .

$$C = 12.01 \text{ g/mol}$$

$$H = 3.03 \text{ g/mol}$$

$$O = 16.00 \text{ g/mol}$$

$$\frac{31.04 \text{ g}}{\text{mol}}$$

$$\frac{62.0 \text{ g}}{\text{mole}} \text{ molar mass}$$

$$\frac{31.04 \text{ g}}{\text{mole}} \text{ empirical mass}$$

$$= 2$$



