Empirical Formulas

**Bellwork:**

**Definitions:**

*Empirical formula: The smallest whole number ratio of atoms (or moles of atoms) present in a compound (or in a mole of the compound). This formula is derived from lab data.*

*Molecular formula: The whole number ratio of atoms present in a compound as it exists in nature. This formula is derived from the empirical formula and the known molecular mass of the compound.*

1. Comparing formulas: Identify the molecular formula and empirical formula for the following compounds:

 MF EF

* 1. Glucose (C6H12O6) \_\_\_ C6H12O6\_\_\_\_­\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_CH2O\_\_\_\_\_\_\_\_\_\_\_\_
	2. Acetic acid (CH3COOH) \_\_\_ CH3COOH \_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_CH2O\_\_\_\_\_\_\_\_\_\_\_\_
	3. Octane (C8H18) \_\_\_\_\_ C8H18\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_C4H9\_\_\_\_\_\_\_\_\_\_\_\_\_
	4. Methane (CH4) \_\_\_\_\_\_ CH4\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_CH4\_\_\_\_\_\_\_\_\_\_\_\_\_\_
	5. Hydrogen Peroxide (H2O2) \_\_\_\_\_\_\_ H2O2\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_OH\_\_\_\_\_\_\_\_\_\_\_\_\_\_
1. What would be the empirical formula of a compound if there are 104.85 grams of Iron and 45.15 grams of oxygen?

$$104.85 g Fe×\frac{1 mole Fe}{55.85 g Fe }=1.877 mol Fe$$

$$45.15 g O×\frac{1 mole O}{15.9994 g O }=2.82 mol O$$

$$\frac{1.877 mol Fe}{1.877 mol Fe}=1 mol F×2=2 Fe$$

$$\frac{2.82 mol O}{1.877 mol Fe}=1.5 mol O×2=3 O$$

Formula\_\_\_\_\_\_\_\_Fe2O3\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_Iron (III) oxide\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. A compound has 73.9 % mercury and 26.1 % Chlorine. What is the empirical formula for this compound?

$$73.9 g Hg×\frac{1 mole Hg}{200.6 g Hg }=0.368 mol Hg$$

$$26.1 g Cl×\frac{1 mole Cl}{35.453 g Cl }=0.736 mol Cl$$

$$\frac{0.368 mol Hg}{0.368 mol Hg}=1 mol Hg$$

$$\frac{0.736 mol Cl}{0.368 mol Hg}=2 mol Cl$$

Formula\_\_\_\_\_\_\_\_\_HgCl2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_Mercury (II) chloride\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What would be the empirical formula for a compound that contains 32.38% Na, 22.65% S, and 44.99% O

$$32.38 g Na×\frac{1 mole Na}{22.99 g Na }=1.41 mol Na$$

$$22.65 g S×\frac{1 mole S}{32.07 g S }=0.706 mol S$$

$$44.99 g O×\frac{1 mole O}{15.9994 g O }=2.81 mol O$$

$$\frac{0.706 mol S}{0.706 mol S}=1 mol S$$

$$\frac{1.41 mol Na}{0.706 mol S}=1.997 mol Na$$

$$\frac{2.81 mol O}{0.706 mol S}=3.98 mol O$$

Formula\_\_\_\_\_\_\_Na2SO4\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_Sodium sulfate\_\_\_\_\_\_\_\_\_\_

1. If I have a molecular weight of 65.1 g and an empirical formula of CH, what is the molecular formula?

Molar mass compound = X x Molar mass of CH

65.1 g/mol compound = X x 13 g/mol CH

$$X=\frac{65.1 g/mol}{13.02 g/mol}=3$$

 Thus, the molecular formula must be **C3H3** for this compound.

1. Determine the empirical formula for a compound that is 56.6% K, 8.7% C, and 34.7% O. Include the name of this compound in your answer.

$$56.6 g K×\frac{1 mole K}{39.10 g K }=1.48 mol K$$

$$8.7 g C×\frac{1 mole C}{12.011 g C }=0.724 mol C$$

$$34.7 g O×\frac{1 mole O}{15.9994 g O }=2.17 mol O$$

$$\frac{0.724 mol C}{0.724 mol C}=1 mol C$$

$$\frac{1.48 mol K}{0.724 mol C}=2.04 mol K$$

$$\frac{2.17 mol O}{0.724 mol C}=2.99 mol O$$

Formula\_\_\_\_K2CO3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_Potassium carbonate\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. A sample was analyzed and found to contain 40.00% carbon, 6.71% hydrogen and 53.29% oxygen. If the molar mass of the compound is 180.16 g/mol, what are the empirical and molecular formulas of the compound?

Determining the empirical formula:

$$40.00 g C×\frac{1 mole C}{12.011 g C }=3.33 mol C$$

$$6.71 g H×\frac{1 mole H}{1.0079 g H }=6.66 mol H$$

$$53.29 g O×\frac{1 mole O}{15.9994 g O }=3.33 mol O$$

$$\frac{3.33 mol C}{3.33 mol C}=1 mol C$$

$$\frac{6.66 mol H}{3.33 mol C}=2 mol H$$

$$\frac{3.33 mol O}{3.33 mol C}=1 mol O$$

Determining the molecular formula:

 Molar Mass of MF: 180.16 g/mol

 Molar Mass of EF: (12.011 g/mol C) + (2 x 1.0079 g/mol H)

+ (15.9994 g/mol O) = 30.026 g/mol CH2O

 180.16 g/mol = X x 30.026 g/mol CH2O

 X = 6, thus the molecular formula is C6H2x6O6.

Formula\_\_\_\_\_\_\_\_C6H12O6\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_glucose\_\_\_\_\_\_\_\_\_\_

1. What is the empirical formula for a hydrate that has 45.44% of it mass from water, 24.77% cobalt, and 29.80% chloride. Include the name of this compound in your answer.

YOU WILL NOT BE REQUIRED TO NAME HYDRATES ON UNIT 6a EXAM!!

$$45.44 g H\_{2}O×\frac{1 mole H\_{2}O}{18.0152 g H\_{2}O }=2.522 mol H\_{2}O$$

$$24.77 g Co×\frac{1 mole Co}{58.93 g Co }=0.4203 mol Co$$

$$29.80 g Cl×\frac{1 mole Cl}{35.453 g Cl }=0.8405 mol Cl$$

$$\frac{0.4203 mol Co}{0.4203 mol Co}=1 mol Co$$

$$\frac{0.8405 mol Cl}{0.4203 mol Co}=1.999 mol Cl$$

$$\frac{2.522 mol H\_{2}O}{0.4203 mol Co}=6.000 mol H\_{2}O$$

Formula\_\_\_\_\_\_\_\_CoCl2•6H2O\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_Cobalt (II) chloride hexahydrate\_\_\_\_\_\_\_\_\_\_\_

# Empirical Formula Challenge Problems

Retrieved from: <http://www.chemteam.info/Mole/BonusEmpFormProbs.html>

1. Calculate the molar mass of a metal that forms an oxide having the empirical formula M2O3 and contains 68.04% of the metal by mass. Identify the metal.

(1) 68.04% of the compound is the metal, therefore 31.96% is oxygen.

(2) The three moles of oxygen weigh 48.0 g and this represents 31.96% of the total weight.

(3) 31.96% is to 48.0 as 100% is to x
x = 150.2

(4) Subtract 48 from 150.2 to get 102.2, which is the weight contribution of M2.

(5) Dividing by two gets 51.1. The nearest atomic weight on the periodic table is 50.9, that of vanadium.

1. Hemoglobin is the oxygen-carrying compound found in human blood. It is found to contain 0.3335% iron by mass. It is already known that one molecule of hemoglobin contains four atoms of iron. What is the molar mass of hemoglobin?

(1) One mole of iron weighs 55.845 g; four of them weigh 223.38

(2) This value (223.38) represents 0.3335% of the total mass of hemoglobin.

(3) 223.38 is to 0.3335% as x is to 100%

(4) x = 66,980 g/mol

Comment: in biochemistry, molecular weights into the tens of thousands are very common. Also, the unit "daltons," as a symbol for g/mol, is often used in biochemistry, as in 66,980 daltons.