WKS 3-10 – Chem Honors
Molecular Formula

NAME Answer Key
Period _____ **Date** _____

Empirical Formula: **The simplest formula for a compound--** simplest whole number ratio. (fully reduced.)

For example: NaCl, CH_2, H_2O, NH_3

Molecular Formula: **Actual formula for the molecule**.

- Sometimes the molecular formula and the empirical formula of a compound are the same.
  Ex: A water molecule is H_2O. Water's empirical formula is also H_2O (fully reduced.)
- However, sometimes the molecular formula of a compound is a multiple of its empirical formula.
  Ex: The molecular formula of ethane gas is C_2H_6, but its empirical formula is CH_3
  Ex: The molecular formula of benzene is C_6H_6, but its empirical formula is CH.

Practice Problems:

1) A compound has an empirical formula of CH_2. The molar mass of the compound is 56.1 g/mole. What is the compound's molecular formula?
   HINT: **Step 1**: What is the molar mass of just the empirical formula? 12.0 + 2(1.02) = 14.0 g/mol
   Note: since the cmpd MM is only 3 SF, more precision is unneeded here
   Step 2: Find out what multiple the molecular formula is to the empirical formula. To do so, plug in:

$$\text{multiple} = \frac{\text{molar mass of molecular formula}}{\text{molar mass of empirical formula}} = \frac{56.1\ \text{g/mol}}{14.0\ \text{g/mol}} = 4.01 \approx 4$$

   Step 3: multiply the empirical formula by this multiple. Write molecular formula.
   $(CH_2) \times 4 = C_4H_8$

2) Glucose, a natural sugar found in fruit, has the empirical formula CH_2O and its molar mass is 180.2 g/mol. What is the molecular formula of glucose?

$$\text{EFM} = 12.01 + 2(1.008) + 16.00 = 30.02\ \text{g/mol};\ \text{multiple} = \frac{180.2\ \text{g/mol}}{30.02\ \text{g/mol}} = 6;\ (CH_2O) \times 6 = \boxed{C_6H_{12}O_6}$$

3) The compound diethyl maleate, used as an additive and intermediate for plastics, pigments, pharmaceuticals, and agricultural products, has the empirical formula of C_2H_3O and molar mass 172 g/mole. What is its molecular formula?

$$\text{EFM} = 2(12.0) + 3(1.01) + 16.0 = 43.0\ \text{g/mol};\ \text{Multiple} = \frac{172\ \text{g/mol}}{43.0\ \text{g/mol}} = 4;\ (C_2H_3O) \times 4 = \boxed{C_8H_{12}O_4}$$

4) It is experimentally determined that a sample of the stimulant caffeine contains 49.5% C, 5.15% H, 28.9% N, and 16.5% O.
   a) What is the empirical formula of caffeine?

$$\text{C: } 49.5\ \text{g} \times \frac{1\ \text{mol}}{12.0\ \text{g}} = 4.13\ \text{mol C} \div 1.03 = 4 \qquad \text{H: } 5.15 \times \frac{1\ \text{mol}}{1.01\ \text{g}} = 5.10\ \text{mol H} \div 1.03 = 4.95 \approx 5$$
$$\text{N: } 28.9\ \text{g} \times \frac{1\ \text{mol}}{14.0\ \text{g}} = 2.06\ \text{mol N} \div 1.03 = 2 \qquad \text{O: } 16.5\ \text{g O} \times \frac{1\ \text{mol}}{16.0\ \text{g}} = 1.03\ \text{mol O} \div 1.03 = 1$$

$\Rightarrow \boxed{C_4H_5N_2O}$

   b) The molar mass of caffeine is 195 g/mole. What is caffeine's molecular formula?

$$\text{EFM} = 4(12.0) + 4(1.01) + 2(14.0) + 16.0 = 96.0\ \text{g/mol};\ \text{Multiple} = \frac{195\ \text{g/mol}}{96.0\ \text{g/mol}} \approx 2;\ (C_4H_5N_2O) \times 2 = \boxed{C_8H_{10}N_4O_2}$$