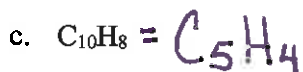
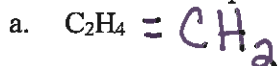


## Empirical and Molecular Formulas Practice Problems:

1. Determine the empirical formula for each of the following molecular formulas:



The empirical formula can be the same as the molecular formula since these subscripts will not reduce.

2. A chemist determines that a sample contains 10.52 grams of nickel, 4.38 grams of carbon, and 5.10 grams of nitrogen. Determine the empirical formula.

$$10.52 \text{ g Ni} \times \frac{1 \text{ mol Ni}}{58.69 \text{ g Ni}} = 0.1792 \text{ mol Ni} \div 0.1792 = 1 \text{ Ni}$$

$$4.38 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 0.3647 \text{ mol C} \div 0.1792 = 2 \text{ C}$$

$$5.10 \text{ g N} \times \frac{1 \text{ mol N}}{14.01 \text{ g N}} = 0.3640 \text{ mol N} \div 0.1792 = 2 \text{ N}$$



3. MSG is a compound that is frequently added to Asian foods as a flavor enhancer. An analysis of this compound showed that MSG is 35.5% C, 4.77% H, 8.29% N, 13.6% Na, and 37.9% O. Find the empirical formula for MSG.

$$35.5 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 2.9559 \text{ mol C} \div 0.5916 = 5 \text{ C}$$

$$4.77 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 4.7228 \text{ mol H} \div 0.5916 = 8 \text{ H}$$

$$13.6 \text{ g Na} \times \frac{1 \text{ mol Na}}{22.99 \text{ g Na}} = 0.5916 \text{ mol Na} \div 0.5916 = 1 \text{ Na}$$

$$8.29 \text{ g N} \times \frac{1 \text{ mol N}}{14.01 \text{ g N}} = 0.5917 \text{ mol N} \div 0.5916 = 1 \text{ N}$$

$$37.9 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 2.3688 \text{ mol O} \div 0.5916 = 4 \text{ O}$$



4. Karelite is a rare mineral. It's composition is 56.0 % vanadium and 44.0% oxygen. Determine the empirical formula for this mineral.

$$56.0 \text{ g V} \times \frac{1 \text{ mol V}}{50.94 \text{ g V}} = 1.099 \text{ mol V} \div 1.099 = 1 \text{ V}$$

$$44.0 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 2.75 \text{ mol O} \div 1.099 = 2.5 \text{ O}$$

$\text{V}_1\text{O}_{2.5}$  Multiply to get subscripts to be whole numbers.

$$\text{empirical} = \text{V}_2\text{O}_5$$

5. A compound contains 40.7% C, 54.2 % O, and 5.1 % H. Determine its empirical formula.

$$40.7 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 3.388 \text{ mol C} \div 3.3875 = 1 \text{ C}$$

$$54.2 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 3.3875 \text{ mol O} \div 3.3875 = 1 \text{ O}$$

$$5.1 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 5.0495 \text{ mol H} \div 3.3875 = 1.49 \text{ H}$$

$\text{C}_1\text{O}_1\text{H}_{1.5}$  Multiply so that subscripts will be whole numbers.

$$\text{empirical} = \text{C}_2\text{O}_2\text{H}_3$$

6. Teflon is used as a nonstick lining in pans. It is 24.0% C and 76.0% F and has a molar mass of 100.0 g/mol. Find the empirical and molecular formula for Teflon.

$$24.0 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 1.998 \text{ mol C} \div 1.998 = 1 \text{ C}$$

$$76.0 \text{ g F} \times \frac{1 \text{ mol F}}{19.00 \text{ g F}} = 4 \text{ mol F} \div 1.998 = 2 \text{ F}$$

empirical =  $\text{CF}_2$  mass of empirical = 50.01 g/mol

$$\frac{100.0 \text{ g/mol}}{50.01 \text{ g/mol}} = 2$$

Multiply empirical formula by 2 to get molecular formula:  $\text{C}_2\text{F}_4$

7. Styrene is a derivative of benzene and is produced as a precursor for other foam products. Analysis shows that the compound is 92.25% C and 7.75% H with a molar mass of 104 g/mol. Determine the empirical and molecular formula for styrene.

$$92.25 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 7.681 \text{ mol C} \div 7.681 = 1 \text{ C}$$

$$7.75 \text{ g H} \times \frac{1 \text{ mol H}}{1.008 \text{ g H}} = 7.69 \text{ mol H} \div 7.681 = 1 \text{ H}$$

empirical formula = CH

molar mass of empirical = 13.02 g/mol

$$\frac{104 \text{ g/mol}}{13.02 \text{ g/mol}} = 8$$

Multiply the empirical formula by 8 to get a molecular formula of  $\text{C}_8\text{H}_8$

8. If you have a headache you have probably taken an ibuprofen tablet. Ibuprofen has a molar mass of 206 g/mol and a percent composition of 75.7% C, 8.80% H, and 15.5% O. Determine the empirical and molecular formula of this common headache remedy.

$$75.7 \text{ g C} \times \frac{1 \text{ mol C}}{12.01 \text{ g C}} = 6.303 \text{ mol C} \div 0.969 = 6.5$$

$$8.80 \text{ g H} \times \frac{1 \text{ mol H}}{1.01 \text{ g H}} = 8.713 \text{ mol H} \div 0.969 = 9$$

$$15.5 \text{ g O} \times \frac{1 \text{ mol O}}{16.00 \text{ g O}} = 0.969 \text{ mol O} \div 0.969 = 1$$

$\text{C}_{6.5}\text{H}_9\text{O}_1$  Multiply so that subscripts are whole numbers:

empirical formula =  $\text{C}_{13}\text{H}_{18}\text{O}_2$

Molar mass of empirical = 206.31 g/mol

Since the molar mass of the empirical and molecular formulas are the same, then the empirical formula and the molecular formula are the same.

molecular formula =  $\text{C}_{13}\text{H}_{18}\text{O}_2$

9. A scientist is studying toxic lead compounds which are dangerous to people's health. One such compound contains lead and chlorine. He conducts an analysis and finds that the compound is 59.37% Pb and the rest chlorine. The molar mass of the compound is 349.0 g/mol. Find the empirical and molecular formulas for this compound.

$$100\% - 59.37\% = 40.63\% \text{ Cl}$$

$$59.37\text{g Pb} \times \frac{1\text{mol Pb}}{207.2\text{g Pb}} = 0.2865\text{mol Pb} \div 0.2865 = 1 \text{ Pb}$$

$$40.63\text{g Cl} \times \frac{1\text{mol Cl}}{35.45\text{g Cl}} = 1.146\text{mol Cl} \div 0.2865 = 4 \text{ Cl}$$

$$\text{empirical} = \text{PbCl}_4$$

Molar mass of empirical = 349.0 g/mol, so therefore the empirical and molecular formula are the same.

10. Glycerol is a thick liquid that can be used in a variety of pharmaceutical and personal care products like cough syrups, toothpaste, hair care products, and soap. It is 39.12% C, 8.75% H, and 52.12% O. The molar mass of the compound is 92.11 g/mol. Find the empirical and molecular formula for glycerol.

$$39.12\text{g C} \times \frac{1\text{mol C}}{12.01\text{g C}} = 3.257\text{mol C} \div 3.257 = 1 \text{ C}$$

$$8.75\text{g H} \times \frac{1\text{mol H}}{1.01\text{g H}} = 8.681\text{mol H} \div 3.257 = 2.66\bar{6} \text{ H}$$

$$52.12\text{g O} \times \frac{1\text{mol O}}{16.00\text{g O}} = 3.258\text{mol O} \div 3.257 = 1 \text{ O}$$

$$\text{empirical formula} = \text{CH}_{2.66\bar{6}}\text{O}$$

Multiply empirical formula by 3 to get subscripts to whole numbers:

$$\text{empirical formula} = \text{C}_3\text{H}_8\text{O}_3$$