

PROBLEM SET: Empirical and Molecular Formulas

What is the empirical formula for a substance made up of:

1) 4.75 g Cs  
4.51 g I

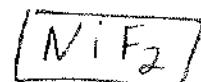
$$4.75 \text{ g Cs} \times 1 \text{ mol} / 132.9 = .03574 \text{ mol Cs}$$



$$4.51 \text{ g I} \times 1 \text{ mol} / 126.9 = .03554 \text{ mol I}$$

2) 9.11 g Ni  
5.89 g F

$$9.11 \text{ g Ni} / 58.7 = .1552 \text{ mol Ni} = 1$$



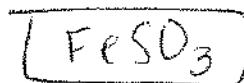
$$5.89 \text{ g F} / 19.0 = .310 \text{ mol F} = 2.0$$

3) 0.0134 g Fe  
0.00769 g S  
0.0115 g O

$$0.0134 \text{ g Fe} = .00024 \text{ mol Fe} = 1$$

$$0.00769 \text{ g S} = .000240 \text{ mol S} = 1$$

$$0.0115 \text{ g O} = .000729 \text{ mol O} = 3$$

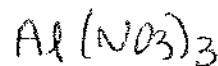
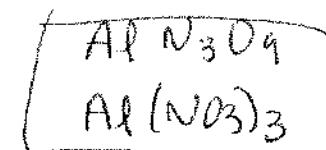


4) 1.21 g Al  
1.88 g N  
6.44 g O

$$1.21 \text{ g Al} = .0448 \text{ mol Al} = 1$$

$$1.88 \text{ g N} = .1343 \text{ mol N} = 3$$

$$6.44 \text{ g O} = .4025 \text{ mol O} = 9$$



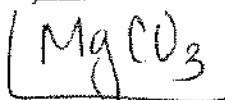
\*assume 100g

5) 28.8% Mg  
14.2% C  
57.0% O

$$28.8\% \text{ Mg} = 28.8 \text{ g} = 1.185 \text{ mol Mg} = 1$$

$$14.2\% \text{ C} = 14.2 \text{ g} = 1.183 \text{ mol C} = 1$$

$$57.0\% \text{ O} = 57.0 \text{ g} = 3.563 \text{ mol O} = 3$$



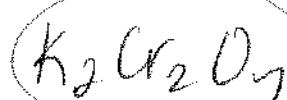
\*assume 100g

6) 26.6% K  
35.3% Cr  
38.1% O

$$26.6\% \text{ K} = 26.6 \text{ g} = 1 \times 2 = 2$$

$$35.3\% \text{ Cr} = 35.3 \text{ g} = 1 \times 2 = 2$$

$$38.1\% \text{ O} = 38.1 \text{ g} = 3.5 \times 2 = 7$$



What is the percent composition of:

- 7)  $\text{Al}_2(\text{SO}_4)_3 = 342.3 \text{ g/mol}$       15.8% Al; 28.1% S; 56.1% O      aluminum sulfate
- 8)  $\text{H}_2\text{SO}_3 = 82.1 \text{ g/mol}$       2.4% H; 39.1% S; 58.5% O      sulfurous acid
- 9)  $\text{Mg}(\text{NO}_3)_2 = 148.3 \text{ g/mol}$       16.4% Mg; 18.9% N; 64.7% O      magnesium nitrate
- 10)  $\text{K}_2\text{CO}_3 = 138.2 \text{ g/mol}$       56.1% K; 8.7% C; 34.7% O      potassium carbonate
- 11)  $\text{CoC}_2\text{O}_4 = 146.9 \text{ g/mol}$       40.1% Co; 16.3% C; 43.6% O      cobalt oxalate
- 12)  $\text{Ba}_3(\text{PO}_4)_2 = 569.9 \text{ g/mol}$       72.3% Ba; 10.9% P; 16.8% O      barium phosphate

13) Next to your answer for each problem above, write the chemical name of the compound.



### More Empirical / Molecular Formula Problems!

14) Chemical analysis of 2-propanol, also known as isopropanol or rubbing alcohol, indicates that it is 60.0% C, 13.4% H, and 26.6% O. What is its empirical formula?

$$\begin{aligned} 60.0 \text{ g C} &= 5.0 \text{ mol C} / 1.66 = 3.0 \text{ C} & (\text{C}_3\text{H}_8\text{O}) \\ 13.4 \text{ g H} &= 13.4 \text{ mol H} / 1.66 = 8 \text{ H} \\ 26.6 \text{ g O} &= 1.66 \text{ mol O} / 1.66 = 1 \text{ O} \end{aligned}$$

15) Determine the empirical formula for a compound that contains 5.717 g of O and 4.433 g of P.

$$\begin{aligned} 5.717 \text{ g O} &= 0.357 \text{ mol O} / 1.43 = 2.5 \text{ O} \times 2 = 5 & (\text{O}_5\text{P}_2) \\ 4.433 \text{ g P} &= 0.143 \text{ mol P} / 1.43 = 1 \text{ P} \times 2 = 2 & (\text{P}_2\text{O}_5) \end{aligned}$$

16) What would be the empirical formula for a compound that contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen?

$$\begin{aligned} 32.38 \text{ g Na} &= 1.408 \text{ mol Na} = 2 & (\text{Na}_2\text{SO}_4) \\ 22.65 \text{ g S} &= 0.706 \text{ mol S} = 1 \\ 44.99 \text{ g O} &= 2.82 \text{ mol O} = 4 \end{aligned}$$

17) The empirical formula of a compound containing phosphorus and oxygen was found to be  $\text{P}_2\text{O}_5$ . Experiments show that the molar mass of the compound is 283.89 g/mol. What is the molecular formula of the compound?

$$\text{P}_2\text{O}_5 = 142.0 \text{ g/mol}$$

$$283.89 / 142 = 2, \text{ so } (\text{P}_4\text{O}_{10})$$

18) Determine the molecular formula of a compound having an empirical formula of CH and a molar mass of 78.11 g/mol.

$$\text{CH} = 13 \text{ g/mol} \quad \frac{78.11}{13} = 6.0 \quad (\text{XCH}) = (\text{C}_6\text{H}_6)$$

19) A compound has the following composition: 76.54% C, 12.13% H, 11.33% O. If its molar mass is 282.45 g/mol, what is its molecular formula?

$$\begin{aligned} 76.54 \text{ g C} &= 6.38 \text{ mol C} = 9 \\ 12.13 \text{ g H} &= 12.13 \text{ mol H} = 17 \\ 11.33 \text{ g O} &= 7.08 \text{ mol O} = 1 \end{aligned} \quad \left( = 141.9 \text{ g/mol} \right)$$

$$282.45 / 141 \approx 2$$

$$2 \times \text{C}_9\text{H}_{17}\text{O}$$

$$= (\text{C}_{18}\text{H}_{34}\text{O}_2)$$

20) Determine the molecular formula for each of the following:

a) a compound with a molar mass of 86.17 g/mol that contains 83.62% C and 16.38% H.

$$83.62 \text{ g C} \times \frac{1 \text{ mol C}}{12.0} = 6.97 \text{ mol C} / 6.97 = 1 \times 3 = 3$$

$$16.38 \text{ g H} \times \frac{1 \text{ mol H}}{1.0} = 16.38 \text{ mol H} / 6.97 = 2.35 \times 3 = 7$$

b) a compound with a molar mass of 92.01 g/mol that contains 0.608 g N and 1.388 g O. actual = 86

$$\cancel{0.608 \text{ g N}} \times \frac{1 \text{ mol}}{14.0} = .0434 = 1$$

$$1.388 \text{ g O} \times \frac{1 \text{ mol}}{16.0} = .0868 = 2$$

$$\text{NO}_2 = 46.0 \text{ g/mol}$$

$$\text{actual} = 92.01 \text{ g/mol}$$

$$(\text{C}_6\text{H}_{14})$$

$$\text{NO}_2 \times 2 = (\text{N}_2\text{O}_4)$$