NS F3 (pg 1 of 2) Determining Empirical Formulas

Name______________________

Empirical formula means the lowest whole number ratio of a chemical compound. Ionic compounds are always written as empirical formulas.

Steps to Follow:

In order to determine the empirical (simplest whole number) formula, use the four-step procedure listed below:

1. Divide each mass (or mass percentage) by the molar mass of the element, which will give the number of moles of each element.
2. Divide the results from step 1 by whichever number of moles is the smallest..
3. If some results are not close enough to whole numbers, multiply all the moles from step 2 by a common factor that will convert all the mole amounts to whole numbers or near whole numbers
   - (In this first-year chem course, you will only use factors of 2 or 3).
4. Round each mole amount to the nearest whole number.

Sample Problem #1:

In LAD 3.4C we measured a 0.540 g strip of magnesium, after burning the strip, the product weighed 0.865 g. Determine the empirical formula of magnesium oxide.

- First you must determine the quantity of oxygen in this compound. Simple subtraction will do it. 0.865 g − 0.540 g =
- Next complete *step 1* outlined above.
  - Mg $0.540g\left(\frac{1mol}{24.31g}\right) = 0.0222mol$ Oxygen: $0.325g\left(\frac{1mol}{16.00g}\right) = 0.0203mol$
- Next proceed to *step 2* outlined above.
  - Mg $\frac{0.0222mol}{0.0203mol} = 1.09$ O $\frac{0.0203mol}{0.0203mol} = 1$
- Steps 3 and 4 are not necessary, the ratio is close enough to whole numbers. Voilà. The formula must be MgO

Sample Problem #2:

Suppose some hydrogen and oxygen compound that was analyzed to be 11.2 % hydrogen. Determine the empirical formula.

- First you must make the assumption that if the compound is 11.2 % hydrogen, the remainder of the compound, 89.8 % must be the oxygen.
- Next complete *step 1* outlined above.
  - H $11.2g\left(\frac{1mol}{1.01g}\right) = 11.1mol$ Oxygen: $88.8g\left(\frac{1mol}{16.00g}\right) = 5.55mol$
- Next proceed to *step 2* outlined above.
  - H $\frac{11.1}{5.55} = 2$ O $\frac{5.55}{5.55} = 1$
- Steps 3 and 4 are not necessary. Voilà. The formula must be H_2O water!

two more sample problems on the back ➙

Sample Problem #3:

Calculate the empirical formula for a compound that was determined to be 80.1% barium, 18.7 % oxygen and 1.2% hydrogen. From the formula, and realizing that the compound is ionic because it is made out of a metal combined with a group of nonmetals, the name of the compound can be determined.

- As before, first do step 1 as outlined above.
    - Ba $80.1g\left(\frac{1mol}{137.3g}\right) = 0.583mol$
    - O $18.7g\left(\frac{1mol}{16.0g}\right) = 1.17mol$
    - H $1.2g\left(\frac{1mol}{1.01g}\right) = 1.19mol$
- Proceed to step 2.
    - Ba $\frac{0.583mol}{0.583mol} = 1$
    - O $\frac{1.17mol}{0.583mol} = 2.006$
    - H $\frac{1.19mol}{0.583mol} = 2.04$
- Since step 3 is not necessary, proceed to step 4.
    - Ba 1
    - O 2.006 close enough 2
    - H 2.064 close enough 2 Voilà. The empirical formula must be BaO_2H_2
- To name this ionic compound, you should realize that since there are two nonmetals attached to the barium (metal) it must be a polyatomic ion, and you could use the polyatomic ion chart to establish its name.
    - Since there is no polyatomic ion O_2H_2 , but there is OH, a factor of 2 can be pulled out.
    - BaO_2H_2 can be converted $Ba(OH)_2$ which is named barium hydroxide.

Sample Problem #4:

Some compound that was analyzed to be 1.55 g of nitrogen and 4.45 g of oxygen.

- As before, do step 1 as outlined above.
    - N $1.55g\left(\frac{1mol}{14.0g}\right) = 0.111mol$
    - O $1.55g\left(\frac{1mol}{16.0g}\right) = 0.278mol$
- Proceed to step 2.
    - N $\frac{0.111mol}{0.111mol} = 1$
    - O $\frac{0.278mol}{0.111mol} = 2.5$
- Proceed to step 3 because there is a non whole number mole value
    - N $1 \times 2 = 2$
    - O $2.5 \times 2 = 5$ Voilà. The formula N_2O_5