

## Empirical Formulas (EF)

- An empirical formula is a chemical formula simplified to its lowest ratio of subscripts
- Determine an empirical formula from % composition or lab data.

(Ex) A compound is found to be  
58.8% Ba, 13.74% S, & 27.43% O.

### Steps

(1) Assume 100g of substance,  
& convert % to g.

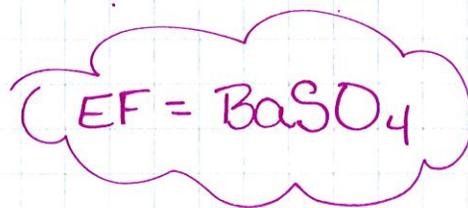
(2) Convert g to moles

(3) Divide all answers  
by the smallest one  
in step 2 to get the  
ratio of the elements  
to each other

(4) If you get whole #'s  
or very close to whole  
#'s, those are the  
subscripts for your  
E.F.

(5) If you get a decimal  
(between .3 → .7),  
you need to multiply  
your answers in step  
**3** by a number that  
will give whole numbers.

$$\begin{array}{r} \frac{58.8\text{g Ba}}{137.33\text{g/mol}} \\ = \frac{.42817\text{mol Ba}}{.42817\text{mol}} \\ = 1 \text{ Ba} \end{array} \quad \begin{array}{r} \frac{13.74\text{g S}}{32.07\text{g/mol}} \\ = \frac{.42844\text{mol S}}{.42817\text{mol}} \\ = 1 \text{ S} \end{array} \quad \begin{array}{r} \frac{27.43\text{g O}}{16.00\text{g/mol}} \\ = \frac{1.7144\text{mol O}}{.42817\text{mol}} \\ = 4 \text{ O} \end{array}$$



Ex) A compound contains.  
 .0134g Fe, .00769g S, &  
 .0115g O. What's its EF?

$$\frac{.0134\text{g Fe}}{55.85\text{g/mol}} \quad \frac{.00769\text{g S}}{32.07\text{g/mol}} \quad \frac{.0115\text{g O}}{16.00\text{g/mol}}$$

$$= .00023993 \text{ mol Fe} \quad = .00023979 \text{ mol S} \quad = .00071875 \text{ mol O}$$

$$\frac{.00023979}{.00023979} \quad \frac{.00023979}{.00023979} \quad \frac{.00071875}{.00023979}$$

$$= 1 \text{ Fe} \quad = 1 \text{ S} \quad = 3 \text{ O}$$



Ex) A compound contains 68.4%  
Cr and the rest is O. Find  
 the EF  $100 - 68.4 = 31.6\% \text{ O}$

$$\frac{68.4\text{g Cr}}{52.00\text{g/mol}} \quad \frac{31.6\text{g O}}{16.00\text{g/mol}}$$

$$= 1.31538 \text{ mol Cr} \quad = 1.975 \text{ mol O}$$

$$\frac{1.31538\text{mol}}{1.31538\text{mol}} \quad \frac{1.975\text{mol}}{1.31538\text{mol}}$$

$$2(1 \text{ Cr}) \quad 2(1.50 \text{ O})$$



## Molecular Formulas (MF)

- A molecular formula is the true chemical formula for a compound
- Determine a molecular formula.

### Steps

- (1) Find the empirical formula (EF)
- (2) Calculate the molar mass of the empirical formula (MMEF)
- (3) Divide the molar mass of the molecular formula (MM<sub>MF</sub>), given in the ? by the MMEF. This gives you the multiple.
- (4) multiply the subscripts in the EF by the multiple to get the MF

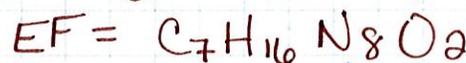
Ex.) A component of the protein, serine, has a molar mass of  $\sim 490$  g. It's % composition is  $34.95\% \text{ C}$ ,  $6.844\% \text{ H}$ ,  $46.56\% \text{ N}$ , and  $13.59\% \text{ O}$ . Find the MF.

$$\frac{34.95 \text{ g C}}{12.01 \text{ g/mol}} = \frac{2.910 \text{ mol C}}{.8494 \text{ mol}} = 2 \left( 3.4 \text{ C} \right)$$

$$\frac{6.844 \text{ g H}}{1.01 \text{ g/mol}} = \frac{6.776 \text{ mol H}}{.8494 \text{ mol}} = 2 \left( 8 \text{ H} \right)$$

$$\frac{46.56 \text{ g N}}{14.01 \text{ g/mol}} = \frac{3.3233 \text{ mol N}}{.8494 \text{ mol}} = 2 \left( 4 \text{ N} \right)$$

$$\frac{13.59 \text{ g O}}{16.00 \text{ g/mol}} = \frac{.8494 \text{ mol O}}{.8494 \text{ mol}} = 2 \left( 1 \text{ O} \right)$$

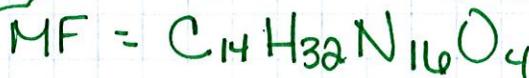


multiply

$$\begin{aligned} \text{MMEF} &= 7 \text{ C} \times 12.01 = 84.07 \\ &16 \text{ H} \times 1.01 = 16.16 \\ &8 \text{ N} \times 14.01 = 112.08 \\ &2 \text{ O} \times 16.00 = 32.00 \\ &\quad + \end{aligned}$$

244.31

$$\frac{\sim 490}{244} = 2$$



Ex) A compound contains 5.93% H and 94.07% O and a molar mass of  $\sim 34$ g. Find the MF.

$$\frac{5.93 \text{ g H}}{1.01 \text{ g/mol}}$$

$$= \frac{5.87129 \text{ mol}}{\text{H}}$$

$$= 5.87129 \text{ mol}$$

$$= 1 \text{ H}$$

$$\frac{94.07 \text{ g O}}{16.00 \text{ g/mol}}$$

$$= \frac{5.87938 \text{ mol}}{\text{O}}$$

$$= 5.87129 \text{ mol}$$

$$= 1 \text{ O}$$



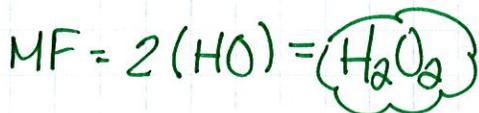
MM<sub>EF</sub>

$$1 \text{ H} \times 1.01 \text{ g} = 1.01 \text{ g}$$

$$1 \text{ O} \times 16.00 \text{ g} = 16.00 \text{ g}$$

$$\hline 17.01 \text{ g}$$

$$\frac{\sim 34 \text{ g}}{17.01 \text{ g}} \approx 2$$



Ex) A rocket propellant is 30.43% N and 69.57% O and has a molar mass of  $\sim 92.0$ g. Find the MF.

$$\frac{30.43 \text{ g N}}{14.01 \text{ g/mol}}$$

$$= \frac{2.17202 \text{ mol N}}{2.17202 \text{ mol}}$$

$$= 1 \text{ N}$$



MM<sub>EF</sub>

$$1 \text{ N} \times 14.01 \text{ g} = 14.01 \text{ g}$$

$$2 \text{ O} \times 16.00 \text{ g} = 32.00 \text{ g}$$

$$\hline 46.01 \text{ g}$$

$$\frac{\sim 92.0 \text{ g}}{46.01 \text{ g}} \approx 2$$

