Practice Problem:

1. Determine the Empirical formula for the 400 gram sample containing 31.5% cobalt, 34.28% sulfur, and 34.22% oxygen.

Answers:

There are TWO possible ways to answer this question… Either method is correct – However, the first method I will show IS FASTER and will give the same result (answer to the question).

Method #1 (Best method):

- Convert the percentage amounts to gram amounts:

31.5% Cobalt = 31.5 grams of Cobalt

34.28% Sulfur = 34.28 grams of Sulfur

34.22% Oxygen = 34.22 grams of Oxygen

- Recall, we are attempting to calculate the Empirical Formula for this compound containing the above element percentages. Empirical Formula states that we have the SMALLEST WHOLE-NUMBER RATIO of elements within the compound.

- AND recall that 1 gram of cobalt does NOT equal the same number of atoms (particles) as 1 gram of sulfur (or 1 gram of oxygen)… HOWEVER, 1 mole of cobalt DOES HAVE the same number of atoms (particles) as 1 mole of sulfur (or 1 mole of oxygen)…

- For this reason, WE MUST convert ALL gram amounts (mass amounts) to MOLES !!!

$$\frac{31.5\ g\ Co}{} \times \frac{1\ mol\ Co}{58.93\ g} = 0.53453\ mol$$

$$\frac{34.28\ g\ S}{} \times \frac{1\ mol\ S}{32.06\ g} = 1.0692\ mol$$

$$\frac{34.22\ g\ O}{} \times \frac{1\ mol\ O}{16.00\ g} = 2.13875\ mol$$

- Now that we have the mole amounts for EACH element, let's determine the RATIO of each of the elements to each other: Compare the mole amounts to each of the SMALLEST mole amount

$$0.53453\ mol\ Co: \frac{0.53453\ mol}{0.53453\ mol} = 1.00$$

$$1.0692\ mol\ S: \frac{1.0692\ mol}{0.53453\ mol} = 2.00$$

$$2.13875\ mol\ O: \frac{2.13875\ mol}{0.53453\ mol} = 4.00$$

The ratio is:

1 : 2 : 4

Empirical Formula:

CoS_2O_4

Method #2 (This works, but more work and steps):

- From the 400 gram sample of the compound - Convert the percentage amounts to gram amounts:

31.5% Cobalt = 400 grams (0.315) = 126 grams Cobalt

34.28% Sulfur = 400 grams (0.3428) = 137.12 grams Sulfur

34.22% Oxygen = 400 grams (0.3422) = 136.88 grams Oxygen

- Again, we are attempting to calculate the Empirical Formula for this compound containing the above element percentages. Empirical Formula states that we have the SMALLEST WHOLE-NUMBER RATIO of elements within the compound.

- AND recall that 1 gram of cobalt does NOT equal the same number of atoms (particles) as 1 gram of sulfur (or 1 gram of oxygen)… HOWEVER, 1 mole of cobalt DOES HAVE the same number of atoms (particles) as 1 mole of sulfur (or 1 mole of oxygen)…

- For this reason, WE MUST convert ALL gram amounts (mass amounts) to MOLES !!!

$$\frac{126\ g\ Co}{} \times \frac{1\ mol\ Co}{58.93\ g} = 2.13813\ mol$$

$$\frac{137.12\ g\ S}{} \times \frac{1\ mol\ S}{32.06\ g} = 4.27698\ mol$$

$$\frac{136.88\ g\ O}{} \times \frac{1\ mol\ O}{16.00\ g} = 8.555\ mol$$

- Do not be concerned that the number of moles for each of the elements is NOT THE SAME as the first method… We are NOT concerned with the number of moles when we solve this question – We ONLY are concerned about the RATIO of moles…

- Now that we have the mole amounts for EACH element, let's determine the RATIO of each of the elements to each other: Compare the mole amounts to each of the SMALLEST mole amount

$$2.13813\ mol\ Co: \frac{2.13813\ mol}{2.13813\ mol} = 1.00$$

$$1.0692\ mol\ S: \frac{4.27698\ mol}{2.13813\ mol} = 2.00$$

$$2.13875\ mol\ O: \frac{2.13875\ mol}{8.555\ mol} = 4.00$$

The ratio is:

1 : 2 : 4

Empirical Formula:

CoS_2O_4

- Now, I, personally, am not concerned with the method (first or second) you plan on using - Just be sure to show ALL your steps (and units) when solving for Empirical Formulas.

2. What is the Empirical formula for a 425.0 gram sample containing 69.94% of iron and 30.06% of oxygen.

Answers:

- ***Convert the percentage amounts to gram amounts:***

69.94% Iron = 69.94 grams of Iron

30.06% Oxygen = 30.06 grams of Oxygen

- ***Convert ALL gram amounts (mass amounts) to moles…***

$$\frac{69.94\ g\ Fe}{} \times \frac{1\ mol\ Fe}{55.85\ g} = 1.25228\ mol$$

$$\frac{30.06\ g\ O}{} \times \frac{1\ mol\ O}{16.00\ g} = 1.87875\ mol$$

- ***Determine the mole ratios for each…***

$$1.25228\ mol\ Fe : \frac{1.25228\ mol}{1.25228\ mol} = 1.00$$

$$1.87875\ mol\ O : \frac{1.87875\ mol}{1.25228\ mol} = 1.50$$

- ***Interesting… We CANNOT have a ratio that has numbers that are NOT all whole numbers… We must eliminate the fractional amounts by multiplying all the values by a number that would eliminate the fractional value… One "really cool" way to determine the number to multiply the numbers by is by taking the decimal value and changing it to a fraction...***

$$1.25228\ mol\ Fe : \frac{1.25228\ mol}{1.25228\ mol} = 1.00$$

$$1.87875\ mol\ O : \frac{1.87875\ mol}{1.25228\ mol} = 1.50 = 1\frac{1}{2}$$

- ***Now multiply all by the value in the denominator of the fraction – this will eliminate any decimal amounts thus having whole numbers…***

$$1.25228\ mol\ Fe : \frac{1.25228\ mol}{1.25228\ mol} = 1.00 \times 2 = 2$$

$$1.87875\ mol\ O : \frac{1.87875\ mol}{1.25228\ mol} = 1.50 = 1\frac{1}{2} \times 2 = 3$$

The ratio is:

2 : 3

Empirical Formula:

Fe_2O_3