Problem Set 4.2 - Multiple proportions

The law of multiple proportions states that whenever two elements form two different compounds and the mass of one of the elements in both compounds is the same, the masses of the other element in the two compounds will be a small whole number ratio.

So, for example, there is a red oxide of copper and a black oxide of copper. If we use 10.0 g of copper to make a sample of both red and black copper oxide, the mass of oxygen used in the two samples will be a small whole number ratio. If we look at this same example quantitatively:

Red copper oxide is 88.8% copper. Black copper oxide is 79.9% copper. Let’s suppose each sample of oxide contains 10.0 g of copper. If this is true, the mass of oxygen in each will be:

 Red: Black:

88.8% = [(10.0 g copper) / (x grams red copper oxide)] x 100% 79.9% = [(10.0 g copper) / (x grams black copper oxide)] x 100%

 x = 11.26 grams of red copper oxide x = 12.52 grams of black copper oxide

So the mass of oxygen in each is:

 Red: Black:

 = 11.26 grams of red copper oxide – 10.0 g copper = 12.52 grams of black copper oxide – 10.0 g copper

 = 1.26 grams of oxygen. = 2.52 grams oxygen.

The ratio of the mass of oxygen in the red copper oxide : mass of oxygen in the black copper oxide is

 1.26 g : 2.52 g

Simplifying (dividing by the smallest value)

 1 : 2

Whenever there are two different compounds with the same elements, the mass ratio of one of the elements will always be a small, whole number **provided the mass of the other element is the same in both samples**. It will not always be 1:2, but will always be a small, whole number ratio. (2:3, 3:4 1:3, etc.)

**Questions for Understanding:**

1. Two oxides of Iron are 77.7% iron and 63.6% iron. Demonstrate that these two compounds follow the law of multiple proportions. Suggest some possible chemical formulas of these two oxides of iron.
2. There are two compounds of copper chloride. One is 64.2% copper and the other is 47.2% copper. Suggest the chemical formulae of the two compounds by using the law of multiple proportions.
3. Two oxides of nickel are 78.6% nickel and 71.0% nickel. Show the chemical formulae of the two compounds of nickel oxide by using the law of multiple proportions.
4. \*If carbon dioxide is 27.3% carbon, what is the percent composition of carbon monoxide? Show your calculations.