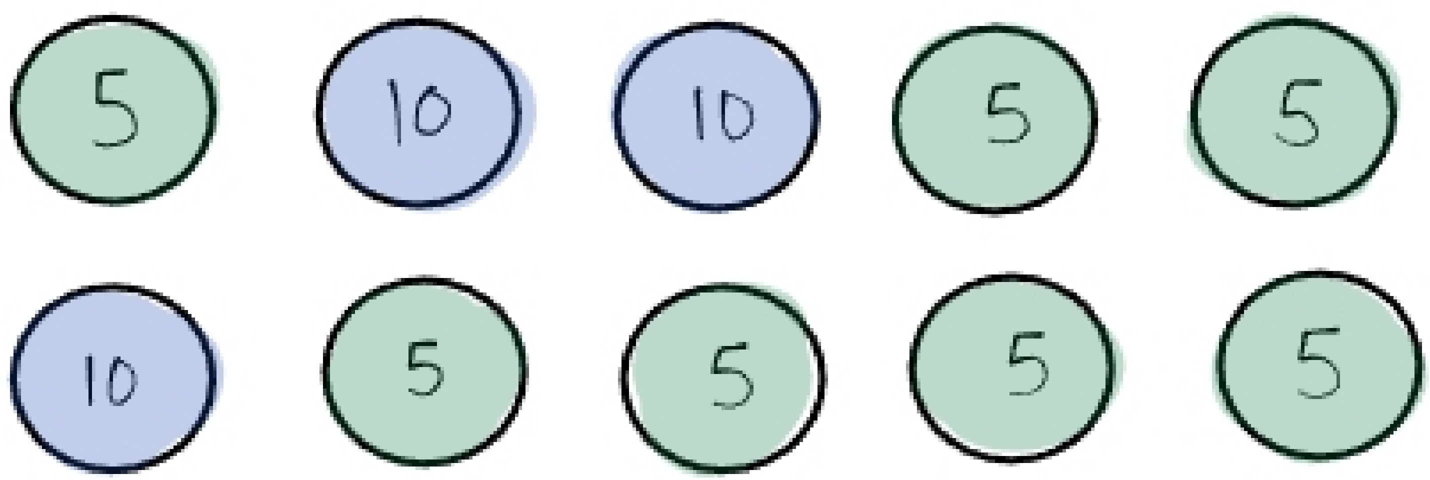
Most students grasp the concept of isotopes: atoms of the same element that differ in mass number because of a different number of neutrons in the nucleus. What students tend to have a hard time with is how to calculate isotopic mass given percent abundance, or vice versa. The following tutorial hopes to explain this concept in detail.

Calculating average isotopic mass requires a strong understanding of how averages work. Consider the following:




Here we have ten coins. Some have a value of 5 units, and some have a value of 10 units. If we wanted to calculate the average value of all the coins above, we would add up all of their individual values (65) and divide by the total number of coins (10). The average value of the coins is 6.5 units.

But what if we had hundreds of thousands of coins? How would we calculate the average then? Technically, we could add up all of their values and divide the total by the number of coins we had. But there's a better way, and that's to use a representative sample.

Suppose that the coins above are a representative sample (a sample that exhibits the same proportion of components as the total) of the hundreds of thousands of coins we want to find an average for. We can use the percent abundance of each coin, and each coin's individual value, to find the overall average.

What percentage of the coins have a value of 5 units? 7/10 = 70%

What percentage of the coins have a value of 10 units? 3/10 = 30%

We can calculate the average value of all all of the coins by multiplying each percentage (in decimal form) by its respective value, and then adding the two numbers together:

$$5(0.70) = 3.5 \text{ units}$$
$$10(0.30) = 3.0 \text{ units}$$
$$\overline{\quad 6.5 \text{ units}}$$

As you can see, the averages are the same using both methods. The second method, however, is how we calculate the average atomic masses that you see on the periodic table. Speaking of, let's do some examples that are actually related to chemistry.

Calculating Average Atomic Mass Given Percent Abundance

Example 1: There are two known naturally occurring isotopes of copper: copper-62 and copper-64. Given that the percent abundance of Cu-62 is 24.3%, calculate the average atomic mass (in amu) of copper.

$$\text{Average Atomic Mass} = (\%)(m) + (\%)(m) + \ldots$$

The equation above includes the ellipses to show that you could have more than two naturally occurring isotopes for an element, and that it too would have to be included in the average mass. But in this example, we only have two, so let's write what we know and then substitute the information into the equation.

Cu-62

% = 24.3 = 0.243

m = 62 amu

Cu-64

% = (100% − 24.3%) = 75.7% = 0.757

m = 64 amu

Average mass = (62 amu)(0.243) + (64 amu)(0.757)

= 15.066 amu + 48.448 amu

= 63.514 amu

Example 2: What is the average atomic mass (in amu) of silicon if the only known isotopes are Si-26 (24.9%), Si-28 (49.7%), and Si-30 (25.4%)?

Average mass = (26 amu)(0.249) + (28 amu)(0.497) + (30 amu)(0.254)

= 6.474 amu + 13.916 amu + 7.620 amu

= 28.01 amu

Calculating Percent Abundance Given Average Atomic Mass

In the previous examples, we were given the identity of the isotopes and their individual atomic masses and asked to calculate the average atomic mass for the element. In the following example, we will work out problems in which we calculate the percent abundance of each isotope given the average atomic mass. These problems will test your algebra skills, so pay close attention to how each value is substituted into the formula.

Example 3: The average atomic mass of iodine is 126.90 amu. The two naturally occurring isotopes of iodine are I-126 and I-128. Calculate the percent abundance of each isotopic species.

We will use the same equation from before, but with a slight modification:

$$\text{Average Atomic Mass} = (x)(m) + (1-x)(m) + \ldots$$

The x in this equation represents the unknown abundance of the first isotope, in decimal form. The 1-x represents the percent abundance of the second isotope, in relation to the first. We subtract from 1 because 1 is the decimal form of 100%. And now, to work out our example:

$$126.90\text{ amu} = (x)(126\text{ amu}) + (1-x)(128\text{ amu})$$

$$= 126x + 128\text{ amu} - 128x$$

$$126.90\text{ amu} = -2x + 128\text{ amu}$$

$$-1.1 = -2x$$

$$x = 0.55 = 55.0\%$$

| I-126 | I-128 |
| --- | --- |
| 55.0% | 45.0% |