Math Tutor WEIGHTED AVERAGES AND ATOMIC MASS

You have learned that the mass of a proton is about 1 amu and that a neutron is only slightly heavier. Because atomic nuclei consist of whole numbers of protons and neutrons, you might expect that the atomic mass of an element would be very near a whole number. However, if you look at the periodic table, you will see that the atomic masses of many elements lie somewhere between whole numbers. In fact, the atomic masses listed on the table are *average* atomic masses. The atomic masses are averages because most elements occur in nature as a specific mixture of isotopes. For example, 75.76% of chlorine atoms have a mass of 34.969 amu, and 24.24% have a mass of 36.966 amu. If the isotopes were in a 1:1 ratio, you could simply add the masses of the two isotopes together and divide by 2. However, to account for the differing abundance of the isotopes, you must calculate a *weighted average.* For chlorine, the weighted average is 35.45 amu. The following two examples demonstrate how weighted averages are calculated.

SAMPLE 1

Naturally occurring silver consists of 51.839% Ag-107 (atomic mass 106.905 093) and 48.161% Ag-109 (atomic mass 108.904 756). What is the average atomic mass of silver?

To find average atomic mass, convert each percentage to a decimal equivalent and multiply by the atomic mass of the isotope.

$$0.518\,39 \times 106.905\,093 \text{ amu} = 55.419 \text{ amu}$$
$$0.481\,61 \times 108.904\,756 \text{ amu} = 52.450 \text{ amu}$$
$$107.869 \text{ amu}$$

Adding the masses contributed by each isotope gives an average atomic mass of 107.869 amu. Note that this value for the average atomic mass of silver is very near the one given in the periodic table.

SAMPLE 2

Naturally occurring magnesium consists of 78.99% Mg-24 (atomic mass 23.985 042), 10.00% Mg-25 (atomic mass 24.985 837), and 11.01% Mg-26 (atomic mass 25.982 593). What is the average atomic mass of magnesium?

Again, convert each percentage to a decimal and multiply by the atomic mass of the isotope to get the mass contributed by each isotope.

$$0.7899 \times 23.985\,042 \text{ amu} = 18.95 \text{ amu}$$
$$0.1000 \times 24.985\,837 \text{ amu} = 2.499 \text{ amu}$$
$$0.1101 \times 25.982\,593 \text{ amu} = 2.861 \text{ amu}$$
$$24.31 \text{ amu}$$

Adding the masses contributed by each isotope gives an average atomic mass of 24.31 amu.

PRACTICE PROBLEMS

1. Rubidium occurs naturally as a mixture of two isotopes, 72.17% Rb-85 (atomic mass 84.911 792 amu) and 27.83% Rb-87 (atomic mass 86.909 186 amu). What is the average atomic mass of rubidium?

2. The element silicon occurs as a mixture of three isotopes: 92.22% Si-28, 4.69% Si-29, and 3.09% Si-30. The atomic masses of these three isotopes are as follows: Si-28 = 27.976 926 amu, Si-29 = 28.976 495 amu, and Si-30 = 29.973 770 amu.

   Find the average atomic mass of silicon.