Skills to Develop

- Explain what is meant by the atomic mass of an element.
- Calculate the atomic mass of an element from the masses and relative percentages of the isotopes of the element.

In chemistry we very rarely deal with only one isotope of an element. We use a mixture of the isotopes of an element in chemical reactions and other aspects of chemistry, because all of the isotopes of an element react in the same manner. That means that we rarely need to worry about the mass of a specific isotope, but instead we need to know the average mass of the atoms of an element. Using the masses of the different isotopes and how abundant each isotope is, we can find the average mass of the atoms of an element. The **atomic mass** of an element is the weighted average mass of the atoms in a naturally occurring sample of the element. Atomic mass is typically reported in atomic mass units.

### Calculating Atomic Mass

You can calculate the atomic mass (or average mass) of an element provided you know the **relative abundances** (the fraction of an element that is a given isotope), the element's naturally occurring isotopes, and the masses of those different isotopes. We can calculate this by the following equation:

$$\text{Atomic mass} = \left( \%_1 \right) \left( \text{mass}_1 \right) + \left( \%_2 \right) \left( \text{mass}_2 \right) + \cdots$$

Look carefully to see how this equation is used in the following examples.

Example $$\PageIndex{1}$$: Boron Isotopes

Boron has two naturally occurring isotopes. In a sample of boron, $$20\%$$ of the atoms are $$\ce{B}\text{-10}$$, which is an isotope of boron with 5 neutrons and mass of $$10 \text{ amu}$$. The other $$80\%$$ of the atoms are $$\ce{B}\text{-11}$$, which is an isotope of boron with 6 neutrons and a mass of $$11 \text{ amu}$$. What is the atomic mass of boron?

**SOLUTION**

Boron has two isotopes. We will use the equation:

$$\text{Atomic mass} = \left( \%_1 \right) \left( \text{mass}_1 \right) + \left( \%_2 \right) \left( \text{mass}_2 \right) + \cdots$$

- Isotope 1: $$\left( \%_1 = 0.20 \right)$$ (Write all percentages as decimals), $$\text{mass}_1 = 10$$
- Isotope 2: $$\left( \%_2 = 0.80 \right), \text{mass}_2 = 11$$

Substitute these into the equation, and we get:

$$\text{Atomic mass} = 0.20 \times 10 + 0.80 \times 11 = 10.8 \text{ amu}$$

The mass of an average boron atom, and thus boron’s atomic mass, is $$10.8 \text{ amu}$$.

Example $$\PageIndex{2}$$: Neon Isotopes
Neon has three naturally occurring isotopes. In a sample of neon, \(90.92\%\) of the atoms are \(\text{Ne}-20\), which is an isotope of neon with 10 neutrons and a mass of \(19.99 \: \text{amu}\). Another \(0.3\%\) of the atoms are \(\text{Ne}-21\), which is an isotope of neon with 11 neutrons and a mass of \(20.99 \: \text{amu}\). The final \(8.85\%\) of the atoms are \(\text{Ne}-22\), which is an isotope of neon with 12 neutrons and a mass of \(21.99 \: \text{amu}\). What is the atomic mass of neon?

**SOLUTION**

Neon has three isotopes. We will use the equation:

\[
\text{Atomic mass} = \left( \%_1 \right) \left( \text{mass}_1 \right) + \left( \%_2 \right) \left( \text{mass}_2 \right) + \cdots
\]

- Isotope 1: \(\%_1 = 0.9092\) (write all percentages as decimals), \(\text{mass}_1 = 19.99\)
- Isotope 2: \(\%_2 = 0.003\), \(\text{mass}_2 = 20.99\)
- Isotope 3: \(\%_3 = 0.0885\), \(\text{mass}_3 = 21.99\)

Substitute these into the equation, and we get:

\[
\text{Atomic mass} = \left( 0.9092 \right) \left( 19.99 \right) + \left( 0.003 \right) \left( 20.99 \right) + \left( 0.0885 \right) \left( 21.99 \right)
\]

\[
\text{Atomic mass} = 20.17 \: \text{amu}
\]

The mass of an average neon atom is \(20.17 \: \text{amu}\).

The periodic table gives the atomic mass of each element. The atomic mass is a number that usually appears below the element's symbol in each square. Notice that the atomic mass of boron (symbol \(\text{B}\)) is 10.8, which is what we calculated in Example \(\PageIndex{1}\), and the atomic mass of neon (symbol \(\text{Ne}\)) is 20.8, which is what we calculated in Example \(\PageIndex{2}\). Take time to notice that not all periodic tables have the atomic number above the element's symbol and the mass number below it. If you are ever confused, remember that the atomic number should always be the smaller of the two and will be a whole number, while the atomic mass should always be the larger of the two and will be a decimal number.

**Exercise \(\PageIndex{1}\)**

Chlorine has two naturally occurring isotopes. In a sample of chlorine, \(75.77\%\) of the atoms are \(\text{Cl}-35\), with a mass of \(34.97 \: \text{amu}\). Another \(24.23\%\) of the atoms are \(\text{Cl}-37\), with a mass of \(36.97 \: \text{amu}\). What is the atomic mass of chlorine?

**Answer:**

35.45 amu

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**Summary**

- An element's atomic mass is the weighted average of the masses of the isotopes of an element
- An element's atomic mass can be calculated provided the relative abundances of the element's naturally occurring isotopes and the masses of those isotopes are known.
• The periodic table is a convenient way to summarize information about the different elements. In addition to the element's symbol, most periodic tables will also contain the element's atomic number and the element's atomic mass.

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