**Lesson #6 – Calculating Average Atomic Mass**

**Key Points**

* An element can have differing numbers of neutrons in its nucleus, but it always has the same number of protons. The versions of an element with different neutrons have different masses and are called isotopes.
* The average atomic mass for an element is calculated by summing the masses of the element’s isotopes, each multiplied by its natural abundance on Earth.
* When doing any mass calculations involving elements or compounds, always use average atomic mass, which can be found on the periodic table.

**Key Terms**

* **mass number**: The total number of protons and neutrons in an atomic nucleus.
* **natural abundance**: The abundance of a particular isotope naturally found on the planet. Described in units of %.
* **average atomic mass**: The mass calculated by summing the masses of an element’s isotopes, each multiplied by its natural abundance on Earth.

The atomic number of an element defines the element’s identity and signifies the number of protons in the nucleus of one atom. For example, the element hydrogen will always have one proton in its nucleus. The element helium will always have two protons in its nucleus.

**Isotopes**

Atoms of the same element can, however, have differing numbers of neutrons in their nucleus. For example, stable helium atoms exist that contain either one or two neutrons, but both atoms have two protons. These different types of helium atoms have different masses (3 or 4 atomic mass units), and they are called isotopes.

For any given isotope, the sum of the numbers of protons and neutrons in the nucleus is called the **mass number.** This is because each proton and each neutron weigh one atomic mass unit (amu) relatively speaking. By adding together, the number of protons and neutrons and multiplying by 1 amu, you can calculate the mass of the atom. However, the actual atomic mass of any isotope is not a perfect whole number because the mass of every atom is determined relative to the mass of Carbon-12. Only Carbon-12 has a mass of exactly 12.000 amu. Therefore you will find the masses of individual isotopes to be slightly off from whole numbers, but only by a small degree.

All elements exist as a collection of isotopes. The word ‘isotope’ comes from the Greek ‘isos’ (meaning ‘same’) and ‘topes’ (meaning ‘place’) because the elements can occupy the same place on the periodic table while being different in subatomic construction.

**Calculating Average Atomic Mass**

The average atomic mass of an element is the sum of the masses of its isotopes, each multiplied by its natural abundance (the decimal associated with percent of atoms of that element that are of a given isotope).

The average atomic mass of an element can be found on the periodic table, typically under the elemental symbol. When data are available regarding the natural abundance of various isotopes of an element, it is simple to calculate the average atomic mass.

* For helium, there is approximately one isotope of Helium-3 for every million isotopes of Helium-4; therefore, the average atomic mass is very close to 4 amu (4.002602 amu).
* Chlorine consists of two major isotopes, one with 18 neutrons (75.76 percent of natural chlorine atoms) and one with 20 neutrons (24.24 percent of natural chlorine atoms). The atomic number of chlorine is 17 (it has 17 protons in its nucleus).

The average atomic mass of an element is the sum of the masses of its isotopes, each multiplied by its natural abundance. This means you multiple the % of each element by its atomic mass.

To calculate the average mass, first convert the percentages into decimals (divide them by 100). Then, calculate the mass numbers. The chart below shows the exact atomic masses and natural abundances of the two naturally occurring chloring isotopes.

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| --- | --- | --- |
| **Isotopes of Chlorine** | **Atomic mass (amu)** | **Natural Abundance** |
| Chlorine-35 | 34.96885 | 75.76% |
| Chlorine-37 | 36.965902 | 24.24% |

You multiply 34.96885 x 0.7576 = 26.49 amu

You multiply 36.965902 x 0.2424 = 8.961 amu

Average Atomic Mass of Chlorine is 35.45 amu

See if you can calculate Boron’s average atomic mass from the data below.

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| --- | --- | --- |
| **Isotopes of Chlorine** | **Atomic mass (amu)** | **Natural Abundance** |
| Boron-10 | 10.012937 | 19.99% |
| Boron-11 | 11.009305 | 80.01% |