2.3 Atomic Mass and Number

Mass of Subatomic Particles

Even though electrons, protons, and neutrons are all types of subatomic particles, they are not all the same size. When comparing the masses of electrons, protons, and neutrons, you will find that electrons have an extremely small mass compared to the masses of either protons or neutrons, just like the mass of a penny so extremely small compared to the mass of a bowling ball. On the other hand, the masses of protons and neutrons are fairly similar, with the mass of a neutron being slightly greater than the mass of a proton. Because protons and neutrons are so much more massive than electrons, almost all of the atomic mass in any atom comes from the nucleus, which is where all of the neutrons and protons are located.

The table below, gives the properties and locations of electrons, protons, and neutrons. The third column shows the masses of the three subatomic particles in grams. The second column, however, shows the masses of the three subatomic particles in amu, or atomic mass units. An **atomic mass unit (amu)** is defined as one-twelfth the mass of a carbon-12 atom (a carbon that has 6 protons and 6 neutrons). Atomic mass units are useful because, as you can see, the mass of a proton and the mass of a neutron are almost exactly 1.0 in this unit system.

Subatomic Particles, Properties, and Location

Particle	**Relative Mass (amu)**	**Electric Charge**	**Location**
electron	$\frac{1}{1840}$	-1	outside nucleus
proton	1	$+1$	nucleus
neutron	1	0	nucleus

In addition to mass, another important property of subatomic particles is the charge. The fourth column in the table above shows the charges of the three subatomic particles. You already know that neutrons are neutral and thus have no charge at all. Therefore, we say that neutrons have a charge of zero. What about electrons and protons? Electrons are negatively charged and protons are positively charged, but the positive charge on a proton is exactly equal in magnitude (magnitude means “absolute value”) to the negative charge on an electron. In other words, a neutral atom must have exactly one electron for every proton. If a neutral atom has 1 proton, it must have 1 electron. If a neutral atom has 2 protons, it must have 2 electrons. If a neutral atom has 10 protons, it must have 10 electrons. Do you get the idea?

2.3 Atomic Mass and Number

Elemental Symbol

There are currently over 115 known elements. These elements vary widely in their abundance. For example, only five elements; oxygen, silicon, aluminum, iron and calcium, account for over 90% of the Earth's crust. Similarly, three elements, oxygen, carbon, and hydrogen male up over 90% of the human body.

In order to make chemistry easier for you, scientist gave each element a symbol. The element symbol consists of 1 or 2 letters, with the first letter always being a capital letter. The symbols are mostly derived from their English name for the element but there are a few elements whose symbol is derived from their Greek or Latin name.

The table below shows common elements and their symbol.

Carbon	C	Aluminum	Al	Copper	Cu (from *cuprum*)
Fluorine	F	Barium	Ba	Iron	Fe (from *ferrum*)
Hydrogen	H	Calcium	Ca	Lead	Pb (from *plumbum*)
Iodine	I	Chlorine	Cl	Mercury	Hg (from *hydrargyrum*)
Nitrogen	N	Helium	He	Potassium	K (from *kalium*)
Oxygen	O	Magnesium	Mg	Silver	Ag (from *argentum*)
Phosphorus	P	Platinum	Pt	Sodium	Na (from *natrium*)
Sulfur	S	Silicon	Si	Tin	Sn (from *stannum*)

Atomic Number

Scientists can distinguish between different elements by counting the number of protons. If an atom has only one proton, we know it's an atom of the element hydrogen. An atom with two protons is always an atom of the element helium. When scientists count four protons in an atom, they know it's a beryllium atom. An atom with three protons is a lithium atom, an atom with five protons is a boron atom, an atom with six protons is a carbon atom… the list goes on.

Since an atom of one element can be distinguished from an atom of another element by the number of protons in the nucleus, scientists are always interested in this number and how this number differs between different elements. Therefore, scientists give this number a special name and a special symbol. An element's **atomic number** is equal to the number of protons in the nuclei of any of its atoms. The periodic table gives the atomic number of each element. The atomic number is a whole number usually written above the chemical symbol of each element in the table. The atomic number for hydrogen is 1 because every hydrogen atom has 1proton. The atomic number for helium is 2 because every helium atom has 2 protons. What is the atomic number of carbon? (*Answer*: Carbon has 6 protons, so the atomic number for carbon is 6.)

Since neutral atoms have to have one electron for every proton, an element's atomic number also tells you how many electrons are in a neutral atom of that element. For example, hydrogen has atomic number of 1. This means that an atom of hydrogen has one proton and, if it's neutral, one electron. Gold, on the other hand, has atomic number of 79, which means that a neutral atom of gold has 79 protons and 79 electrons.

2.3 Atomic Mass and Number

Mass Number

The **mass number** of an atom is the total number of protons and neutrons in its nucleus. Why do you think that the mass number includes protons and neutrons, but not electrons? You know that most of the mass of an atom is concentrated in its nucleus and that the mass of an electron is very, very small compared to the mass of either a proton or a neutron (like the mass of a penny compared to the mass of a bowling ball). By counting the number of protons and neutrons, scientists will have a very close approximation of the total mass of an atom.

mass number = (number of protons) + (number of neutrons)

An atom's mass number is very easy to calculate once you know the number of protons and neutrons in the atom. Notice that the mass number is not the same as the mass of the atom. You can easily relate the mass number to the mass by recalling that both protons and neutrons have a relative mass of 1 amu.

Example 1:
What is the mass number of an atom that contains 3 protons and 4 neutrons?

(number of protons) = 3
(number of neutrons) = 4
mass number = (number of protons) + (number of neutrons)
mass number = (3) + (4) = 7

The periodic table of elements provides you with two values; the atomic number (protons) and the atomic mass (average mass of an element based on the abundance of each of its isotopes). The periodic table does not tell you the number of neutrons that exist in the most abundant isotope. To calculate the number of neutrons you subtract the atomic number from the atomic mass (rounded to the nearest whole number).

How does the Periodic Table fit into this?

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. The mass number for boron is 5; this The atomic mass of boron (symbol B) is 10.8. To determine the number of neutrons we round 10.8 to 11 and subtract the atomic number (5) and get 6; therefore, boron has 6 neutrons.

Take time to notice that not all periodic tables have the atomic number above the element's symbol and the atomic mass 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. (The atomic mass must include both the number of protons and the average number of neutrons.) The mass number is **NOT** included on the periodic table.

Resources:
Crash Course Chemistry #1 - The Nucleus
https://www.youtube.com/watch?v=FSyAehMdpyI&index=2&list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr