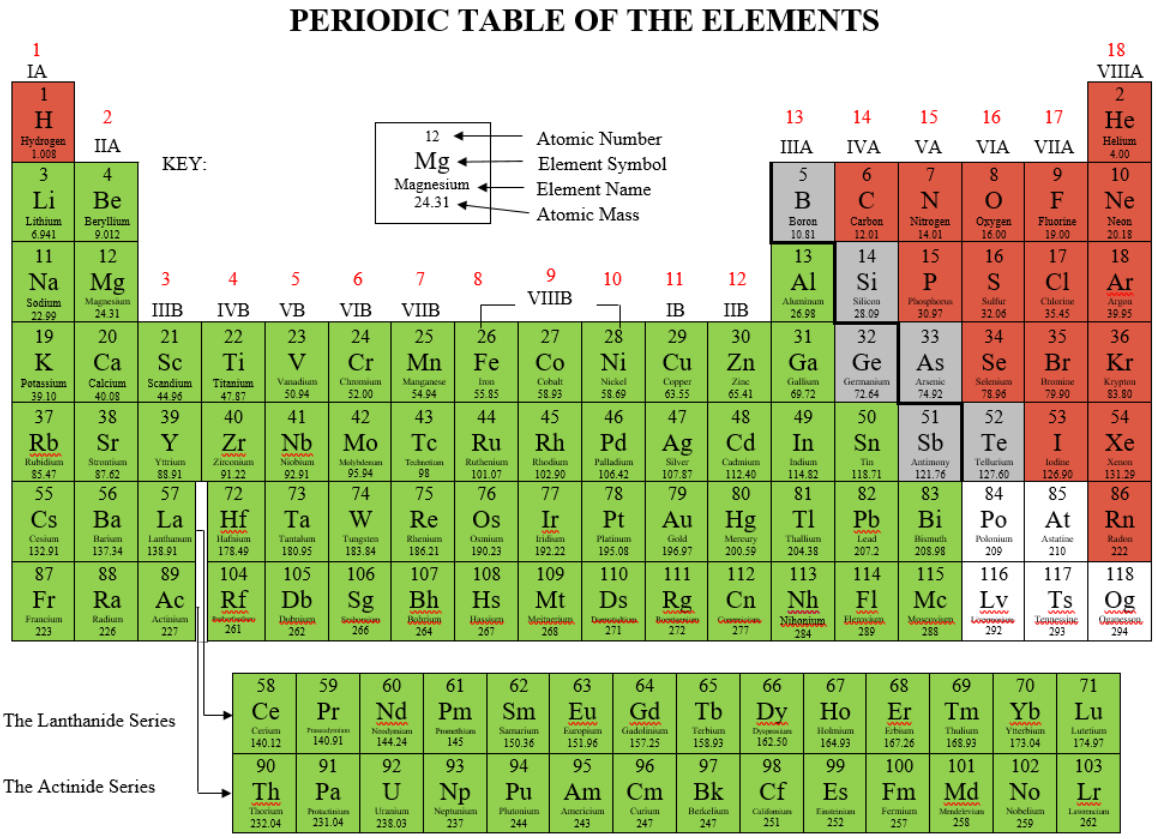
1.2: A First Look at the Periodic Table

Building Blocks

Chemistry involves studying the interaction of the basic building blocks of nature. These building blocks are the atoms of the 118 known elements. People often get confused about atoms and elements. Atoms are the smallest particle of an element that exhibit the properties of that element. An analogy for elements and atoms is Legos^{TM}. Each Lego piece is an atom, and each shape represents an element. Thus, all cube-shaped Lego pieces with one "peg" on top, regardless of color, could represent H atoms, and all rectangular box pieces with two pegs on top, regardless of color, could represent He atoms. In nature, the defining feature of each element is the number of protons in the nucleus, which is called the **atomic number** of that element. Chemists created an organized chart of the elements called the Periodic Table of the Elements. In the most common format of the table, the elements are arranged in order of increasing atomic numbers.

The periodic table is not simply a grid of elements arranged numerically. In the periodic table, the elements are arranged in horizontal rows called periods, and into vertical columns called groups. These groups are numbered by two, somewhat conflicting, schemes. In the simplest presentation, favored by the International Union of Pure and Applied Chemistry (**IUPAC**), the groups are simply numbered 1-18. The convention in much of the world, however, is to number the first two groups IA and IIA, the last six groups IIIA-VIIIA; the middle ten groups are then numbered IB-VIIIB (but not in that order!). While the IUPAC numbering appears much simpler, in this class we will use the "old-fashioned" nomenclature (IA-VIIIA). The reason for this choice will become more apparent in later chapters when we discuss “valence" electrons and bonding. The actual layout of the periodic table is based on the grouping of the elements according to chemical properties. For example, elements in each group of the periodic table (each vertical column) will share many of the same chemical properties. As we discuss the properties of elements and the ways they combine with other elements, the reasons for this particular arrangement of the periodic table will become more obvious.



As you can see, each element in the periodic table is represented by a box containing the chemical symbol, the atomic number (the number of protons in the nucleus) and the atomic mass of the element. As we will discover, the atomic mass is the weighted

average of the masses of all of the natural isotopes of the particular element.

The elements can be classified in many ways. For instance, elements in Groups IA – VIIIA are called the representative, or main group, elements, and the elements in Groups IB - VIIIB are called the transition metals. The broadest classification of elements is into **metals**, **metalloids** (or **semi-metals**) and **nonmetals**. The metallic elements are shown in green on the table here. Metals are solids at room temperature (except for mercury), can conduct electricity, and are usually malleable (can be rolled into sheets) and ductile (can be drawn into wires). Metals are usually separated into the main group metals in Groups IA - VA and the transition metals in Groups IB - VIIIB. Nonmetals (red in the figure) do not conduct electricity well or at all, and have a variety of physical states (some are solids, some liquids and some gases). At the border between metals and nonmetals lie the elements boron, silicon, germanium, arsenic, antimony and tellurium. These elements share physical properties of metals and nonmetals and are called metalloids, or semi-metals. The common semiconductors silicon and germanium are in this group, and it is their unique electrical properties that make transistors and other solid-state devices possible. The elements Po, At, Lv, Ts, and Og are all fairly rare elements, and there is some discussion about how they should be classified. We will not concern ourselves with them.

Named Families

Group IA: The Alkali Metals

The alkali metals are lithium, sodium, potassium, rubidium, cesium, and francium. The name "alkali" comes from an Arabic term related to ashes from burned plants. These ashes contain large amounts of potassium and sodium compounds that form basic aqueous solutions. The compounds of the alkali metals are common in nature and daily life. One example is table salt (sodium chloride); lithium compounds are used in greases, in batteries, and as drugs to treat patients who exhibit manic-depressive, or bipolar, behavior. Although lithium, rubidium, and cesium are relatively rare in nature, and francium is so unstable and highly radioactive that it exists in only trace amounts, sodium and potassium are the seventh and eighth most abundant elements in Earth’s crust, respectively. **Note**: Hydrogen is generally placed in Group 1, but it is **not** an alkali metal.

Group IIA: The Alkaline Earth Metals

The alkaline earth metals are beryllium, magnesium, calcium, strontium, barium, and radium. The name "alkaline earth" comes from the fact that the oxides of the metals in this family were called "earths", and when these compounds are placed in water, the solution becomes basic. Beryllium, strontium, and barium are rare, and radium is unstable and highly radioactive. In contrast, calcium and magnesium are the fifth and sixth most abundant elements on Earth, respectively; they are found in huge deposits of limestone and other minerals.

Group VIIA: The Halogens

The halogens are fluorine, chlorine, bromine, iodine, astatine, and tennessine. The name halogen is derived from the Greek words for “salt forming,” which reflects that all the halogens react readily with metals to form compounds, such as sodium chloride and calcium chloride (used in some areas as road salt).

Compounds that contain the fluoride ion are added to toothpaste and the water supply to prevent dental cavities. Fluorine is also found in Teflon coatings on kitchen utensils. Although chlorofluorocarbon propellants and refrigerants are believed to lead to the depletion of Earth’s ozone layer and contain both fluorine and chlorine, the latter is responsible for the adverse effect on the ozone layer. Bromine and iodine are less abundant than chlorine, and astatine is so radioactive that it exists in only negligible amounts in nature.

Group VIIIA: The Noble Gases

The noble gases are helium, neon, argon, krypton, xenon, radon, and oganesson. Because the noble gases are composed of only single atoms, they are called monatomic elements. At room temperature and pressure, they are unreactive gases. This lack of reactivity led to their name, in that "noble" elements would not interact with the rest of the elements. Because of their lack of reactivity, for many years they were also called inert gases or rare gases. However, the first chemical compounds containing the noble gases were prepared in 1962. Although the noble gases are relatively minor constituents of the atmosphere, natural gas contains substantial amounts of helium. Because of its low reactivity, argon is often used as an unreactive (inert) atmosphere for welding and in light bulbs. The red light emitted by neon in a gas discharge tube is used in neon lights.

Contributors

- Paul R. Young, Professor of Chemistry, University of Illinois at Chicago, Wiki: AskTheNerd; PRY@askthenerd.com - pyoung@uic.edu; ChemistryOnline.com
- Tom Neils (Grand Rapids Community College)

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