

Chapter 5 The Periodic Table

Summary

5.1 Organizing the Elements

An organized table of the elements is one of the most useful tools in chemistry. The placement of elements on the table shows the link between the atomic structure of elements and their properties.

In the 1860s, a Russian chemist named Dmitri Mendeleev discovered a strategy for organizing all the elements known at that time. Mendeleev arranged the elements into rows in order of increasing mass. This arrangement put elements with similar properties in the same column. Within a column, the masses of elements increased from top to bottom.

Mendeleev's chart was an example of a periodic table. A periodic table is an arrangement of elements in columns, based on a set of properties that repeat from row to row.

When Mendeleev made his table, many elements had not yet been discovered. He had to leave spaces in his table for those elements. Mendeleev inferred that the empty spaces in his table would be filled by new elements. He used the properties of elements located near the blank spaces in his table to predict properties for undiscovered elements. Some scientists used the predictions to help in their search for undiscovered elements.

As new elements were discovered, their properties were remarkably similar to the properties that Mendeleev had predicted the elements would have. The close match between Mendeleev's predictions and the actual properties of new elements showed how useful his periodic table could be.

5.2 The Modern Periodic Table

In the modern periodic table, elements are arranged by increasing atomic number (number of protons). Each row in the periodic table is called a period. The number of elements per period varies because the number of available orbitals increases from energy level to energy level.

Each column on the periodic table is called a group. The elements within each group have similar properties. Properties of elements repeat in a predictable way when atomic numbers are used to arrange elements into groups. The elements in a group have similar electron configurations. Therefore, members of a group in the periodic table have similar chemical properties. This pattern of repeating properties displayed by elements on the periodic table is called the periodic law.

There are four pieces of information for each element on the periodic table:

- name
- symbol
- atomic number
- atomic mass

The atomic mass is a value that depends on two factors—how common an element's isotopes are in nature and the masses of those isotopes.

In order to compare the masses of atoms, scientists chose one isotope to serve as a standard. Scientists assigned 12 atomic mass units to the carbon-12 atom, which has 6 protons and 6 neutrons. An atomic mass unit (amu) is defined as one twelfth the mass of a carbon-12 atom. On the periodic table, the atomic mass of an element is given in atomic mass units.

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The periodic table presents three different ways to classify elements:

- Elements are classified as solids, liquids, or gases, based on their states at room temperature. The symbols for solids are black, for liquids are purple, and for gases are red.
- Elements are divided into those that occur naturally and those that do not. The symbols for elements that do not occur naturally are white.
- Elements are classified as metals, nonmetals, and metalloids. Metals are located on the left, nonmetals are on the right, and metalloids are in between.

Metals are elements that are good conductors of electric current and heat. Except for mercury, metals are solid at room temperature. Most metals are malleable. Many metals are ductile—they can be drawn into thin wires.

The metals in groups 3 through 12 are called transition metals. Transition metals form a bridge between the elements on the left and right sides of the table. One property of many transition metals is their ability to form compounds with distinctive colors.

Nonmetals are elements that are poor conductors of heat and electric current. Many nonmetals are gases at room temperature. All the gases on the periodic table are nonmetals.

Metalloids are elements with properties that fall between those of metals and nonmetals. For example, a metalloid's ability to conduct electric current varies with temperature.

Across a period from left to right, elements become less metallic and more nonmetallic in their properties.

5.3 Representative Groups

A valence electron is an electron that is in the highest occupied energy level of an atom. These electrons play a key role in chemical reactions. Elements in a

group have similar properties because they have the same number of valence electrons.

The elements in Group 1A are called alkali metals. The alkali metals include lithium, sodium, potassium, rubidium, cesium, and francium. These metals have a single valence electron, and they are extremely reactive. Because they are so reactive, alkali metals are found in nature only in compounds. Not all the elements in a group are equally reactive. The reactivity of alkali metals increases from the top of Group 1A to the bottom.

The elements in Group 2A are called alkaline earth metals. The alkaline earth metals include beryllium, magnesium, calcium, strontium, barium, and radium. All alkaline earth metals have two valence electrons. Metals in Group 2A are harder than metals in Group 1A. Differences in reactivity among the alkaline earth metals are shown by the ways they react with water. Calcium, strontium, and barium react easily with cold water. Magnesium will react with hot water. No change appears to occur when beryllium is added to water.

Group 3A contains the metalloid boron, the well-known metal aluminum, and three less familiar metals (gallium, indium, and thallium). All these elements have three valence electrons. Aluminum is the most abundant metal in Earth's crust. It is often found combined with oxygen in a mineral called bauxite.

Group 4A contains a nonmetal (carbon), two metalloids (silicon and germanium), and two metals (tin and lead). Each of these elements has four valence electrons. Life on Earth would not exist without carbon. Except for water, most of the compounds in your body contain carbon. Silicon is the second most abundant element in Earth's crust.

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Group 5A contains two nonmetals (nitrogen and phosphorus), two metalloids (arsenic and antimony), and one metal (bismuth). Group 5A includes elements with a wide range of physical properties. Despite their differences, all the elements in Group 5A have five valence electrons. Nitrogen is used to produce fertilizers. Besides nitrogen, fertilizers often contain phosphorus.

Group 6A has three nonmetals (oxygen, sulfur, and selenium), and two metalloids (tellurium and polonium). All the elements in Group 6A have six valence electrons. Oxygen is the most abundant element in Earth's crust.

The elements in Group 7A are called halogens. The halogens include four

nonmetals (fluorine, chlorine, bromine, and iodine) and one metalloid (astatine). Each halogen has seven valence electrons. Fluorine and chlorine are gases, bromine is a liquid, and iodine and astatine are solids. Despite their physical differences, the halogens have similar chemical properties.

The elements in Group 8A are called noble gases. The noble gases include helium, neon, argon, krypton, xenon, and radon. Helium has two valence electrons. Each of the other noble gases has eight valence electrons. The noble gases are colorless and odorless and extremely unreactive.