



APPENDIX

A

The Periodic Table

The periodic table of elements is a very useful means of accessing information in chemistry. Its organization began with the work of the Russian chemist, Dimitri Mendeleev, in the late 1800s.

Organization

Each block in the periodic table contains the symbol for an element, its atomic number (a whole number), and its atomic mass (a decimal number). The elements are arranged in order of increasing atomic number, and a horizontal row on the periodic table is called a *period*. Moving from left to right across each period of the periodic table, the number of electrons in the atoms of each element increases by one. Each vertical column is called a *group*. Each member of the group has the same valence electrons and the same Lewis dot diagrams. (A **Lewis dot diagram** shows the symbol of the element and dots representing its outermost layer of electrons.)

The first period contains only two elements, hydrogen and helium. Hydrogen has a single valence electron and helium has two valence electrons. Each period following the first period also begins with a group 1 metallic element and ends with a noble gas. Between groups 1 and 18, the elements' properties change progressively from metallic to nonmetallic. This relationship of properties and increasing atomic numbers is known as the *periodic law*.

In the second and third rows of the periodic table the atomic numbers increase by eight. This corresponds to the addition of a valence electron with each new group. The addition of the transi-

Periodic Table of the Elements

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | | | | | | | | | | | | | | | | | | |
| 1 | 1 1.00794 H | 2 4 Li | 3 2.016 He | | | | | | | | | | 5 2.012 B | 6 2.011 C | 7 2.016 N | 8 2.016 O | 9 2.016 F | 10 2.016 Ne | | | | | | | | | | | | | | | | | | | |
| 2 | 3 2.016 Li | 4 9 Be | 5 2.016 B | 6 2.011 C | 7 2.016 N | 8 2.016 O | 9 2.016 F | 10 2.016 Ne | | | | | 11 2.016 Na | 12 2.016 Mg | 13 2.016 Al | 14 2.016 Si | 15 2.016 P | 16 2.016 S | 17 2.016 Cl | 18 2.016 Ar | | | | | | | | | | | | | | | | | |
| 3 | 11 2.016 Na | 12 2.016 Mg | 13 2.016 Al | 14 2.016 Si | 15 2.016 P | 16 2.016 S | 17 2.016 Cl | 18 2.016 Ar | | | | | 19 2.016 K | 20 2.016 Ca | 21 2.016 Sc | 22 2.016 Ti | 23 2.016 V | 24 2.016 Cr | 25 2.016 Mn | 26 2.016 Fe | 27 2.016 Co | 28 2.016 Ni | 29 2.016 Cu | 30 2.016 Zn | 31 2.016 Ga | 32 2.016 Ge | 33 2.016 As | 34 2.016 Se | 35 2.016 Br | 36 2.016 Kr | | | | | | | |
| 4 | 19 2.016 K | 20 2.016 Ca | 21 2.016 Sc | 22 2.016 Ti | 23 2.016 V | 24 2.016 Cr | 25 2.016 Mn | 26 2.016 Fe | 27 2.016 Co | 28 2.016 Ni | 29 2.016 Cu | 30 2.016 Zn | 31 2.016 Ga | 32 2.016 Ge | 33 2.016 As | 34 2.016 Se | 35 2.016 Br | 36 2.016 Kr | | | | | | | | | | | | | | | | | | | |

KEY

Atomic Mass → 12.0111 ← Selected Oxidation States
 Symbol → **C** ← Relative atomic masses are based on ¹²C = 12.000
 Atomic Number → 6
 Electron Configuration → 2-4

Note: Mass numbers in parentheses are mass numbers of the most stable or common isotope.

| | | | | | | | | | | | | | | | | | | |
|---|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|-------------------|
| 3 | 21 2.016 Sc | 22 2.016 Ti | 23 2.016 V | 24 2.016 Cr | 25 2.016 Mn | 26 2.016 Fe | 27 2.016 Co | 28 2.016 Ni | 29 2.016 Cu | 30 2.016 Zn | 31 2.016 Ga | 32 2.016 Ge | 33 2.016 As | 34 2.016 Se | 35 2.016 Br | 36 2.016 Kr | | |
| 4 | 39 2.016 Y | 40 2.016 Zr | 41 2.016 Nb | 42 2.016 Mo | 43 2.016 Tc | 44 2.016 Ru | 45 2.016 Rh | 46 2.016 Pd | 47 2.016 Ag | 48 2.016 Cd | 49 2.016 In | 50 2.016 Sn | 51 2.016 Sb | 52 2.016 Te | 53 2.016 I | 54 2.016 Xe | | |
| 5 | 37 2.016 Rb | 38 2.016 Sr | 39 2.016 Y | 40 2.016 Zr | 41 2.016 Nb | 42 2.016 Mo | 43 2.016 Tc | 44 2.016 Ru | 45 2.016 Rh | 46 2.016 Pd | 47 2.016 Ag | 48 2.016 Cd | 49 2.016 In | 50 2.016 Sn | 51 2.016 Sb | 52 2.016 Te | 53 2.016 I | 54 2.016 Xe |
| 6 | 55 2.016 Cs | 56 2.016 Ba | 57 2.016 La | 58 2.016 Ce | 59 2.016 Pr | 60 2.016 Nd | 61 2.016 Pm | 62 2.016 Sm | 63 2.016 Eu | 64 2.016 Gd | 65 2.016 Tb | 66 2.016 Dy | 67 2.016 Ho | 68 2.016 Er | 69 2.016 Tm | 70 2.016 Yb | 71 2.016 Lu | |
| 7 | 87 2.016 Fr | 88 2.016 Ra | 89 2.016 Ac | 90 2.016 Th | 91 2.016 Pa | 92 2.016 U | 93 2.016 Np | 94 2.016 Pu | 95 2.016 Am | 96 2.016 Cm | 97 2.016 Bk | 98 2.016 Cf | 99 2.016 Es | 100 2.016 Fm | 101 2.016 Md | 102 2.016 No | 103 2.016 Lr | |

*The systematic names and symbols for elements of atomic numbers above 109 will be used until the approval of trivial names by IUPAC.

**Denotes the presence of (2-8-) for elements 72 and above

tion elements (metallic elements in groups 3 through 12) increases the size of each period to 18 elements.

Periodic Properties

Repeating patterns of physical and chemical properties of elements in the periodic table are examples of *periodicity*. Each member within a group has very similar properties due to its outer electron configuration. Atomic sizes increase as you go down the elements of each group. As you go across a period, the atomic sizes generally decrease.

Representative elements are those found in groups 1,2,13,14, 15,16,17, and 18. In older periodic tables they are designated as Group A elements and marked as Groups 1A, 2A, 3A, 4A, 5A, 6A, 7A, and 8A. In the middle of the periodic table are the transition metals, or the group B elements (groups 3 through 12 in the newer tables). The elements that are usually placed at the bottom of the periodic table (remember they are parts of periods 6 and 7) are called the *inner transition metals*. They may also be called the Lanthanide and Actinide series after the first element in the row.

The elements on the left-hand side of the periodic table are called *metals*. They are shiny, bendable, ductile, and conduct electricity. On the right-hand side of the periodic table are the *non-metals*. Most of these are gases or liquids at room temperature. They do not conduct electricity and they range from colorless to brightly colored.

A line that separates the metals from the nonmetals runs like a diagonal step across the periodic table on the right side, starting with Boron and ending between Polonium and Astatine. The elements along this line tend to show the characteristics of both metals and nonmetals. Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, Polonium, and Astatine are called *metalloids* or *semi-metals*. They are the elements that make up many of the components found in computers and other electronic devices known as semiconductors.

Valence electrons or the outermost electrons of an element are those that interact with other atoms during chemical bonding. Metals have a tendency to give up or donate their electrons to other elements so that the resulting metal ion will have the electron structure of a noble gas. Nonmetals have a tendency to accept electrons to form ions with a noble gas configuration. As you go down the periodic table, the reactivity of the metals increases. In group 7A or 17, Fluorine is the most reactive element.

Group 1 or 1A elements are called the *alkali metals*. All have a single electron that they give away to form a +1 ion. Sodium will form a Na^+ ion, giving it an electron structure like Neon. The Lewis dot formula for the sodium atom is $\text{Na} \cdot$. Because all group

1 elements have the same outermost electron structure, the Lewis dot formula for any element in this group is $X \cdot$, where X is the symbol for the element.

Group 2 or 2A elements are the second column of the periodic table and are called the alkaline earths. They all have 2 valence electrons and a + valence number. The Lewis dot formula for magnesium is $Mg: \cdot$. The other elements in this group have a similar Lewis diagram.

Group 3A or 13 is called the *boron group*. These elements have +3 valence numbers. Group 4A or 14 is the carbon group, and it may have a valence number of +2 or +4, as well as -4. Group 5A or 15 elements, the nitrogen group, have a valence number of -3, that is, they gain 3 electrons to form a noble gas electron configuration. As you go down this group, note that the elements become more metallic in nature. This is also seen in the carbon group.

Group 6A or 16 is the oxygen group, which has a valence number of -2. These atoms gain 2 electrons to have 8 electrons in their outermost electron shell.

Group 7A or 17 are known as the *halogens*; all the elements in this group have a valence number of -1. The atoms of these elements take an electron from other atoms to complete their outermost electron shell.

Group 8A or 18 elements are called the noble gases because they usually do not react with other elements. Their outermost shell of electrons is completely filled with 8 electrons with the exception of helium, which has only 2 electrons in its filled, outer electron shell.

To summarize, the periodic table can be used to predict:

- which elements can combine with each other
- what types of bonds will form when atoms combine
- the valence number of an element
- which elements are metals, metalloids, or nonmetals
- what the physical state of an element will be
- the atomic number for an element
- common chemical properties of a group