

6.1 How Elements Are Organized

Mendeleev's Periodic Table of the Elements

Mendeleev was a teacher as well as a chemist. He was writing a chemistry textbook and needed a way to organize the elements so it would be easier for students to learn about them. He made a set of cards of the elements, similar to a deck of playing cards, with one element per card. On the card, he wrote the element's name, atomic mass, and known properties. He arranged and rearranged the cards in many different ways, looking for a pattern. He finally found it when he placed the elements in order by atomic mass.

Reihen	Gruppe I. — R ⁰	Gruppe II. — R ⁰	Gruppe III. — R ⁰	Gruppe IV. RH ⁴ R ⁰	Gruppe V. RH ⁵ R ⁰	Gruppe VI. RH ⁶ R ⁰	Gruppe VII. RH R ⁰	Gruppe VIII. — R ⁰
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Tc=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Periodic Table of Elements

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																
1	H Hydrogen 1.00794																		2	He Helium 4.002602															
3	Li Lithium 6.941	4	Be Beryllium 9.012182																	10	Ne Neon 20.1797														
11	Na Sodium 22.98976928	12	Mg Magnesium 24.3050																	18	Ar Argon 39.948														
19	K Potassium 39.0983	20	Ca Calcium 40.078	21	Sc Scandium 44.955912	22	Ti Titanium 47.887	23	V Vanadium 50.9415	24	Cr Chromium 51.9961	25	Mn Manganese 54.938045	26	Fe Iron 55.845	27	Co Cobalt 58.933195	28	Ni Nickel 58.6934	29	Cu Copper 63.546	30	Zn Zinc 65.38	31	Ga Gallium 69.723	32	Ge Germanium 72.64	33	As Arsenic 74.92160	34	Se Selenium 78.96	35	Br Bromine 79.904	36	Kr Krypton 83.796
37	Rb Rubidium 85.4678	38	Sr Strontium 87.62	39	Y Yttrium 88.90585	40	Zr Zirconium 91.224	41	Nb Niobium 92.90638	42	Mo Molybdenum 95.94	43	Tc Technetium (97.9072)	44	Ru Ruthenium 101.07	45	Rh Rhodium 103.92020	46	Pd Palladium 106.42	47	Ag Silver 107.8682	48	Cd Cadmium 112.411	49	In Indium 114.818	50	Sn Tin 118.710	51	Sb Antimony 121.760	52	Te Tellurium 127.60	53	I Iodine 126.90447	54	Xe Xenon 131.293
55	Cs Cesium 132.9054519	56	Ba Barium 137.327	57-71																85	At Astatine (209.9871)	86	Rn Radon (222.0176)												
87	Rf Rutherfordium (261)	88	Ra Radium (226)	89-103																117	Uus Ununseptium (289)	118	Uuo Ununoctium (294)												
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.																																			
Periodic Table Design and Interface Copyright © 1997 Michael Dayah. http://www.ptable.com/ Last updated: May 27, 2008																																			
57	La Lanthanum 138.90547	58	Ce Cerium 140.116	59	Pr Praseodymium 140.90766	60	Nd Neodymium 144.242	61	Pm Promethium (145)	62	Sm Samarium 150.36	63	Eu Europium 151.964	64	Gd Gadolinium 157.25	65	Tb Terbium 158.92535	66	Dy Dysprosium 162.500	67	Ho Holmium 164.93032	68	Er Erbium 167.259	69	Tm Thulium 168.93421	70	Yb Ytterbium 173.054	71	Lu Lutetium 174.967						
89	Ac Actinium (227)	90	Th Thorium 232.03806	91	Pa Protactinium 231.03688	92	U Uranium 238.02891	93	Np Neptunium (237)	94	Pu Plutonium (244)	95	Am Americium (243)	96	Cm Curium (247)	97	Bk Berkelium (247)	98	Cf Californium (251)	99	Es Einsteinium (252)	100	Fm Fermium (257)	101	Md Mendelevium (258)	102	No Nobelium (259)	103	Lr Lawrencium (260)						



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6.2 Classes of Elements

Lesson Objectives

- Identify properties of metals.
- List properties of nonmetals.
- Describe metalloids.
- Relate valence electrons to reactivity of elements by class.

Vocabulary

- metal
- metalloid
- nonmetal
- valence electron

Metals

Metals are elements that are good conductors of electricity. They are the largest of the three classes of elements. In fact, most elements are metals. Look back at the modern periodic table (**Figure 6.3**) in this chapter's lesson "How Elements Are Organized." Find the metals in the table. They are all the elements that are color-coded blue. Examples include sodium (Na), silver (Ag), and zinc (Zn).



Most metals are shiny. That's because they reflect a lot of light. This tray is made mainly of the metal silver (Ag).



Most metals are ductile. This means they can be pulled into long thin shapes, like these wires made of the metal copper (Cu).



Most metals are malleable. This means they can be formed into thin sheets without breaking, like this foil made of the metal aluminum (Al).

Metals have relatively high melting points, so almost all are solids at room temperature. The only exception is mercury (Hg), which is a liquid. Most metals are also good conductors of heat. That's why they are used for cooking pots and stovetops. Metals have other characteristic properties as well. Most are shiny, ductile, and malleable. These properties are illustrated in **Figure 6.5**. You can dig deeper into the properties of metals at this URL: http://www.bc.co.uk/schools/gcsebite/size/science/add_gateway/periodictable/metalsrev1.shtml.

Nonmetals

Nonmetals are elements that do not conduct electricity. They are the second largest class of elements. Find the nonmetals in **Figure 6.3**. They are all the elements on the right side of the table that are color-coded green. Examples of nonmetals include helium (He), carbon (C), and oxygen (O).

Nonmetals generally have properties that are the opposite of those of metals. They also tend to vary more in their properties than metals do. For example, nonmetals have relatively low boiling points, so many of them are gases at room temperature. But several nonmetals are solids, including carbon and phosphorus (P). One nonmetal, bromine (Br), is a liquid at room temperature.

Generally, nonmetals are also poor conductors of heat. In fact, they may be used for insulation. For example, the down filling in a down jacket is mostly air, which consists mainly of nitrogen (N) and oxygen (O). These nonmetal gases are poor conductors of heat, so they keep body heat in and cold air out. Solid nonmetals are dull rather than shiny. They are also brittle rather than ductile or malleable. You can see examples of solid nonmetals in **Figure 6.6**. You can learn more about specific nonmetals with the interactive table at this URL: <http://library.thinkquest.org/3659/pertable/nonmetal.html>.

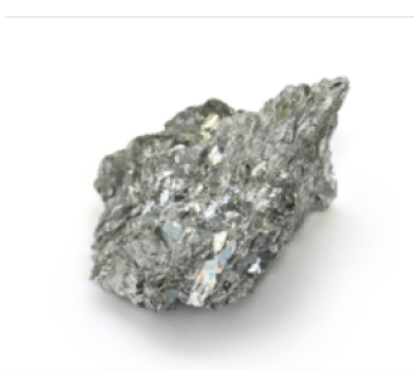
Metalloids

Metalloids are elements that fall between metals and nonmetals in the periodic table. Just seven elements are metalloids, so they are the smallest class of elements. In **Figure 6.3**, they are color-coded orange. Examples of metalloids include boron (B), silicon (Si), and germanium (Ge).

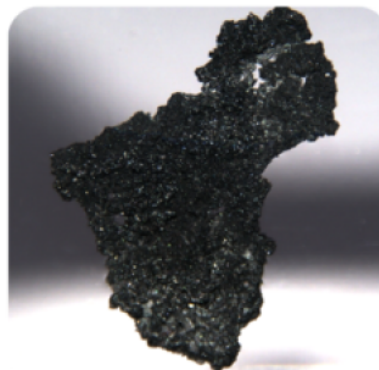
Metalloids have some properties of metals and some properties of nonmetals. For example, many metalloids can conduct electricity but only at certain temperatures. These metalloids are called semiconductors. Silicon is an example. It is used in computer chips. It is also the most common metalloid on Earth. It is shiny like a metal but brittle like a nonmetal. You see a sample of silicon in **Figure 6.7**. The figure also shows other examples of metalloids. You can learn more about the properties of metalloids at this URL: <http://library.thinkquest.org/3659/pertable/metalloid.html>.



Silicon (Si) is a metal that can conduct electricity but not as well as a metal. It is shiny but brittle. It chips easily, like glass.



Antimony (Sb) is a metalloid that is shiny like a metal but brittle like a nonmetal.

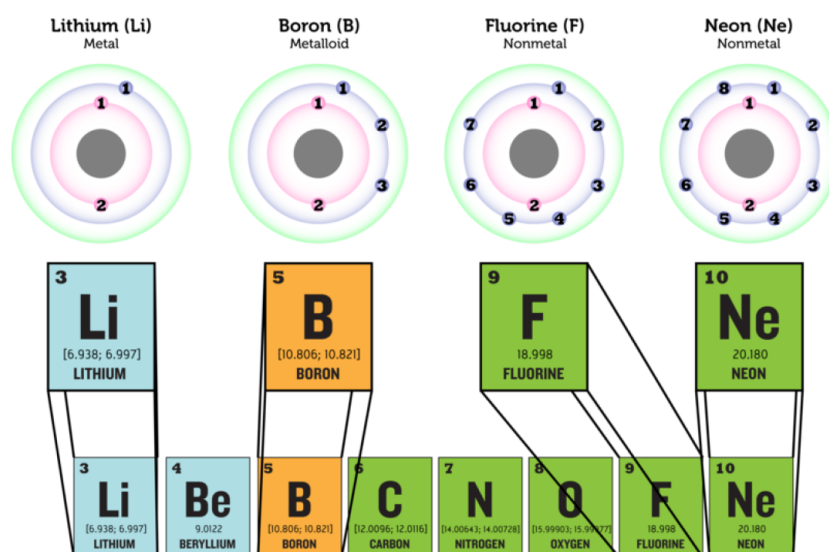


Boron (B) is a metalloid that is somewhat shiny. It also conducts electricity like a metal. However, it is brittle like a nonmetal.

Valence Electrons and Reactivity

The electrons in the outer energy level of an atom are called **valence electrons**. It is valence electrons that are potentially involved in chemical reactions. The number of valence electrons determines an element's reactivity, or how likely the element is to react with other elements. The number of valence electrons also determines whether the element can conduct electric current. That's because electric current is the flow of electrons. **Table 6.1** shows how these properties vary in elements from each class.

- Metals such as lithium have an outer energy level that is almost empty. They "want" to give up their few valence electrons so they will have a full outer energy level. As a result, metals are very reactive and good conductors of electricity.
- Metalloids such as boron have an outer energy level that is about half full. These elements need to gain or lose too many electrons for a full outer energy level to come about easily. As a result, these elements are not very reactive. They may be able to conduct electricity but not very well.
- Some nonmetals, such as bromine, have an outer energy level that is almost full. They "want" to gain electrons so they will have a full outer energy level. As a result, these nonmetals are very reactive. Because they only accept electrons and do not give them up, they do not conduct electricity.
- Other nonmetals, such as neon, have a completely full outer energy level. Their electrons are already in the most stable arrangement possible. They are unreactive and do not conduct electricity.



Element
Boron



Description

Boron (B) is a metalloid. It has three valence electrons and is less reactive than lithium. Boron compounds dissolved in water form boric acid. Dilute boric acid is weak enough to use as eye wash.

Bromine



Bromine (Br) is an extremely reactive nonmetal. This picture shows it reacting with aluminum foil in a test tube. The aluminum starts burning within a couple of minutes of the bromine contacting it.

Lesson Summary

- Metals are elements that are good conductors of electricity. They are the largest class of elements. Many metals are shiny, ductile, and malleable. They are also good conductors of heat. Almost all metals are solids at room temperature.
- Nonmetals are elements that do not conduct electricity. They are the second largest class of elements. Nonmetals are also poor conductors of heat. The majority of nonmetals are gases. Solid nonmetals are dull and brittle.
- Metalloids are elements that have properties of both metals and nonmetals. Some can conduct electricity but only at certain temperatures. They may be shiny but brittle. All metalloids are solids at room temperature.
- Atoms of elements in different classes vary in their number of valence electrons. This explains their differences in reactivity and conductivity.

Pg 133 # 1 - 4, Apply Concepts #1, Think Critically #2

6.3 Groups of Elements

Lesson Objectives

- Identify hydrogen and alkali metals.
- Describe alkaline Earth metals.
- List properties of transition metals.
- Identify groups containing metalloids.
- Give properties of halogens.
- Describe noble gases.