



When we sort parts in our shop or garage, we often classify them in terms of common properties. One container might hold all the screws (possibly sub-divided by size and type). Another container would be for nails. Maybe there is a set of drawers for plumbing parts.

When you get finished, you could also have a collection of things that don't nicely fit a category. You define them in terms of what they are not. They are not electrical components, or sprinkler heads for the yard, or parts for the car. These parts may have some common properties, but are a variety of items.

Nonmetals

In the chemical world, these “spare parts” would be considered nonmetals, loosely defined as not having the properties of metals. A **nonmetal** is an element that is generally a poor conductor of heat and electricity. Most properties of nonmetals are the opposite of metals. There is a wider variation in properties among the nonmetals than among the metals. Nonmetals exist in all three states of matter. The majority are gases, such as nitrogen and oxygen. Bromine is a liquid. A few are solids, such as carbon and sulfur. In the solid state, nonmetals are **brittle**, meaning that they will shatter if struck with a hammer. The solids are not lustrous. Melting points are generally much lower than those of metals. The green elements in the table below are nonmetals.

The periodic table is color-coded as follows:

- Metals (Blue):** Groups 1A, 2A, 3B, 4B, 5B, 6B, 7B, 8B, 9B, 10B, 11B, 12B, 13A, 14A, 15A, 16A, 17A, 18A.
- Metalloids (Orange):** Groups 13A, 14A, 15A, 16A, 17A.
- Nonmetals (Green):** Groups 13A, 14A, 15A, 16A, 17A, 18A.

The periodic table includes the following elements:

Group 1A: H, Li, Na, K, Rb, Cs, Fr

Group 2A: Be, Mg, Ca, Sr, Ba, Ra

Group 3B: Sc, Y, La, Ac

Group 4B: Ti, Zr, Hf, Rf

Group 5B: V, Nb, Ta, Db

Group 6B: Cr, Mo, W, Sg

Group 7B: Mn, Tc, Re, Bh

Group 8B: Fe, Ru, Rh, Pd, Ag, Cd, In, Sn, Sb, Te, I, Xe, Kr, Ar, Ne, He

Group 9B: Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr, Ar, Ne, He

Group 10B: Ni, Cu, Zn, Ga, Ge, As, Se, Br, Kr, Ar, Ne, He

Group 11B: Cu, Ag, Au, Hg, Tl, Pb, Bi, Po, At, Rn, Fr, Ra, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

Group 12B: Zn, Cd, Hg, Tl, Pb, Bi, Po, At, Rn, Fr, Ra, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

Group 13A: B, Al, Ga, In, Sn, Sb, Te, I, Xe, Kr, Ar, Ne, He

Group 14A: C, Si, Ge, As, Se, Br, Kr, Ar, Ne, He

Group 15A: N, P, As, Se, Br, Kr, Ar, Ne, He

Group 16A: O, S, Te, I, Xe, Kr, Ar, Ne, He

Group 17A: F, Cl, Br, I, At, Rn, Fr, Ra, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

Group 18A: He, Ne, Ar, Kr, Xe, Rn, Fr, Ra, Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

Lanthanides: La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu

Actinides: Ac, Th, Pa, U, Np, Pu, Am, Cm, Bk, Cf, Es, Fm, Md, No, Lr

Figure 3.6.2: Copy and Paste Caption here. (Credit: Christopher Auyeung; Source: CK-12 Foundation; License: [CC BY-NC-SA 3.0](#)(opens in new window))

Nonmetals have a wide variety of uses. Sulfur can be employed in gunpowder, fireworks, and matches to facilitate ignition (see Figure below). This element is also widely used as an insecticide, a fumigant, or a means of eliminating certain types of fungus. An important role for sulfur is the manufacture of rubber for tires and other materials. First discovered in 1839 by Charles Goodyear, the process of vulcanization makes the rubber more flexible and elastic as well as being more resistant to changes in temperature. A major use of sulfur is for the preparation of sulfur-containing compounds such as sulfuric acid.



Figure 3.6.3: Sulfur. (Credit: Ben Mills (Wikimedia: Benjah-bmm27); Source: <http://commons.wikimedia.org/wiki/File:Sulfur-sample.jpg>(opens in new window); License: Public Domain)

Bromine is a versatile compound, used mainly in manufacture of flame-retardant materials, especially important for children's clothing (see Figure below). For treatment of water in swimming pools and hot tubs, bromine is beginning to replace chlorine as a disinfectant because of its higher effectiveness. When incorporated into compounds, bromine atoms play important roles in pharmaceuticals for treatment of pain, cancer, and Alzheimer's disease.



Figure 3.6.4: Bromine. (Credit: User:Jurii/Wikimedia Commons; Source: <http://commons.wikimedia.org/wiki/File:Bromine-ampoule.jpg>(opens in new window); License: CC by 3.0(opens in new window))

Helium is one of the many nonmetals that is a gas. Other nonmetal gases include hydrogen, fluorine, chlorine, and all the group eighteen noble (or inert) gases. Helium is chemically non-reactive, so it is useful for applications such as balloons (see figure below) and lasers, where non-flammability is extremely important. Liquid helium exists at an extremely low temperature and can be used to cool superconducting magnets for imaging studies (MRI, magnetic resonance imaging). Leaks in vessels and many types of high-vacuum apparatus can be detected using helium. Inhaling helium changes the speed of sound, producing a higher pitch in your voice. This is definitely an unsafe practice and can lead to physical harm and death.



Figure 3.6.5: Blimp. (Credit: Derek Jensen (Wikimedia: Tysto); Source: <http://commons.wikimedia.org/wiki/File:Goodyear-blimp.jpg>(opens in new window); License: Public Domain)



Summary

- Nonmetals are generally poor conductors of heat and electricity.
- Properties of nonmetals are usually the opposite of properties of metals
- Nonmetals can be solid, liquid, or gas at room temperature depending upon the element.
- Sulfur, bromine, and helium are typical nonmetals.

Review

1. What are the properties of nonmetals?
2. List the states of matter in which nonmetals can exist and give one example of each state.
3. What are the physical properties and uses of sulfur?
4. What are the physical properties and uses of bromine?
5. What are the physical properties and uses of helium?

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