The chemical symbol for aluminum is Al. The superscript refers to the mass number A (27 in the case of aluminum), and the subscript refers to the atomic number Z (13 in the case of aluminum).

An element can be identified by its atomic number, Z. Because the number of protons determines the element, the atomic number of any given element does not change. Thus, the chemical symbol, such as Al, or the name of the element, such as aluminum, can always be used to determine the atomic number. For this reason, the atomic number is sometimes omitted.

Although atomic number does not change within an element, atoms of the same element can have different mass numbers. This is because the number of neutrons in a particular element can vary. Atoms that have the same atomic number but different neutron numbers (and thus different mass numbers) are called **isotopes.** The neutron number for an isotope can be found from the following relationship:

$$A = Z + N$$

This expression says that the mass number of an atom (A) equals the number of protons (Z) plus the number of neutrons (N) in the nucleus of the atom.

The natural abundance of isotopes can vary greatly. For example, $^{11}_{6}C$, $^{12}_{6}C$, $^{13}_{6}C$, and $^{14}_{6}C$ are four isotopes of carbon. The natural abundance of the $^{12}_{6}C$ isotope is about 98.9 percent, while that of the $^{13}_{6}C$ isotope is only about 1.1 percent. Some isotopes do not occur naturally but can be produced in the laboratory. Even the simplest element, hydrogen, has isotopes: $^{1}_{1}H$, called hydrogen; $^{2}_{1}H$, called *deuterium* (or *heavy hydrogen*); and $^{3}_{1}H$, called *tritium* (or *heavy heavy hydrogen*).

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isotope

an atom that has the same number of protons (or the same atomic number) as other atoms of the same element do but that has a different number of neutrons (and thus a different atomic mass)

A nucleus is very dense

Experiments have shown that most nuclei are approximately spherical and that the volume of a nucleus is proportional to the total number of nucleons, and thus to the mass of the nucleus. This suggests that *all nuclei have nearly the same density,* which is about 2.3×10^{17} kg/m^3, which is 2.3×10^{14} times greater than the density of water (1.0×10^3 kg/m^3). Nucleons combine to form a nucleus as though they were tightly packed spheres, as shown in **Figure 2.**

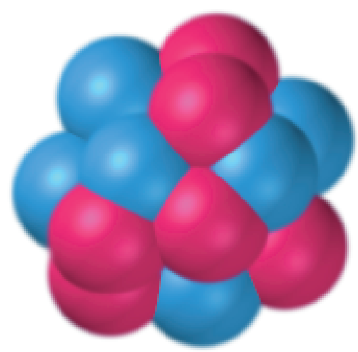

Figure 2
A nucleus can be visualized as a cluster of tightly packed spherical protons and neutrons. This illustration is just a representation; nucleons actually fill very little of the volume of the nucleus and are in rapid motion.

The unified mass unit and rest energy are used to express the mass of a nucleus

Because the mass of a nucleus is extremely small, the *unified mass unit,* u, is often used for atomic masses. This unit is sometimes referred to as the *atomic mass unit.* 1 u is defined so that 12 u is equal to the mass of one atom of carbon-12. That is, the mass of a nucleus (or atom) is measured relative to the mass of an atom of the neutral carbon-12 isotope (the nucleus plus six electrons). Based on this definition, 1 u = $1.660\,538\,86 \times 10^{-27}$ kg. The proton and neutron each have a mass of about 1 u, and the electron has a mass that is only a small fraction of a unified mass unit—about 5×10^{-4} u.