energy than the $4p$ sublevel. Therefore, the five $3d$ orbitals are next to be filled. A total of 10 electrons can occupy the $3d$ orbitals. These are filled successively in the 10 elements from scandium (atomic number 21) to zinc (atomic number 30).

Scandium, Sc, has the electron configuration $[Ar]3d^14s^2$. Titanium, Ti, has the configuration $[Ar]3d^24s^2$. And vanadium, V, has the configuration $[Ar]3d^34s^2$. Up to this point, three electrons with the same spin have been added to three separate d orbitals, as required by Hund's rule.

Surprisingly, chromium, Cr, has the electron configuration $[Ar]3d^54s^1$. Not only did the added electron go into the fourth $3d$ orbital, but an electron also moved from the $4s$ orbital into the fifth $3d$ orbital, leaving the $4s$ orbital with a single electron. Chromium's electron configuration is contrary to what is expected according to the Aufbau principle. However, in reality the $[Ar]3d^54s^1$ configuration is of lower energy than a $[Ar]3d^44s^2$ configuration. For chromium, having six orbitals, all with unpaired electrons, is a more stable arrangement than having four unpaired electrons in the $3d$ orbitals and forcing two electrons to pair up in the $4s$ orbital. On the other hand, for tungsten, W, which is in the same group as chromium, having four electrons in the $5d$ orbitals and two electrons paired in the $6s$ orbital is the most stable arrrangement. Unfortunately, there is no simple explanation for such deviations from the expected order given in **Figure 19.**

Manganese, Mn, has the electron configuration $[Ar]3d^54s^2$. The added electron goes to the $4s$ orbital, completely filling this orbital while leaving the $3d$ orbitals still half-filled. Beginning with the next element, electrons continue to pair in the d orbitals. Thus, iron, Fe, has the configuration $[Ar]3d^64s^2$; cobalt, Co, has the configuration $[Ar]3d^74s^2$; and nickel, Ni, has the configuration $[Ar]3d^84s^2$. Next is copper, Cu, in which an electron moves from the $4s$ orbital to pair with the electron in the fifth $3d$ orbital. The result is an electron configuration of $[Ar]3d^{10}4s^1$—the lowest-energy configuration for Cu.

In atoms of zinc, Zn, the $4s$ sublevel is filled to give the electron configuration $[Ar]3d^{10}4s^2$. In atoms of the next six elements, electrons add one by one to the three $4p$ orbitals. According to Hund's rule, one electron is added to each of the three $4p$ orbitals before electrons are paired in any $4p$ orbital.

Elements of the Fifth Period

In the 18 elements of the fifth period, sublevels fill in a similar manner as in elements of the fourth period. However, they start at the $5s$ orbital instead of the $4s$. Successive electrons are added first to the $5s$ orbital, then to the $4d$ orbitals, and finally to the $5p$ orbitals. This can be seen in **Table 6.** There are occasional deviations from the predicted configurations here also. The deviations differ from those for fourth-period elements, but in each case the preferred configuration has the lowest possible energy.