

4.9: Aufbau Principle



Figure 4.9.1 (Credit: Gary Minnaert; Source: [Commons Wikimedia, File:LACMA BCAM02.jpg](#)(opens in new window) [commons.wikimedia.org]; License: Public Domain)

How are buildings constructed?

Construction of a building begins at the bottom. The foundation is laid, and the building goes up step by step. You obviously cannot start with the roof, since there is no place to hang it. The building goes from the lowest level to the highest level in a systematic way.

Aufbau Principle

In order to create ground state electron configurations for any element, it is necessary to know the way in which the atomic sublevels are organized in order of increasing energy. Figure 4.9.2 shows the order of increasing energy of the sublevels.

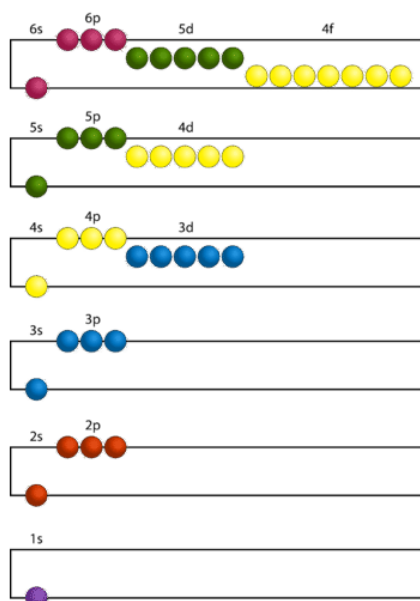


Figure 4.9.2: Electrons are added to atomic orbitals in order from low energy (bottom of the graph) to high (top of the graph), according to the Aufbau principle. Principle energy levels are color coded, while sublevels are grouped together, and each circle represents an orbital capable of holding two electrons. (Credit: Christopher Auyeung; Source: CK-12 Foundation; License: [CC BY-NC 3.0](#)(opens in new window))

The lowest energy sublevel is always the $1s$ sublevel, which consists of one orbital. The single electron of the hydrogen atom will occupy the $1s$ orbital when the atom is in its ground state. As we proceed to atoms with multiple electrons, those electrons are added to the next lowest sublevel: $2s$, $2p$, $3s$, and so on. The **Aufbau principle** states that an electron occupies orbitals in order from lowest energy to highest. The Aufbau (German for *building up, construction*) principle is sometimes referred to as the "building up" principle. It is worth noting that in reality, atoms are not built by adding protons and electrons one at a time, and that this method is merely an aid to understand the end result.

As seen in the figure above, the energies of the sublevels in different principal energy levels eventually begin to overlap. After the $3p$ sublevel, it would seem logical that the $3d$ sublevel should be the next lowest in energy. However, the $4s$ sublevel is slightly lower in energy than the $3d$ sublevel and thus fills first. Following the filling of the $3d$ sublevel is the $4p$, then the $5s$ and the $4d$.

Note that the $4f$ sublevel does not fill until just after the $6s$ sublevel. Figure 4.9.2 is a useful and simple aid for keeping track of the order of fill of the atomic sublevels.

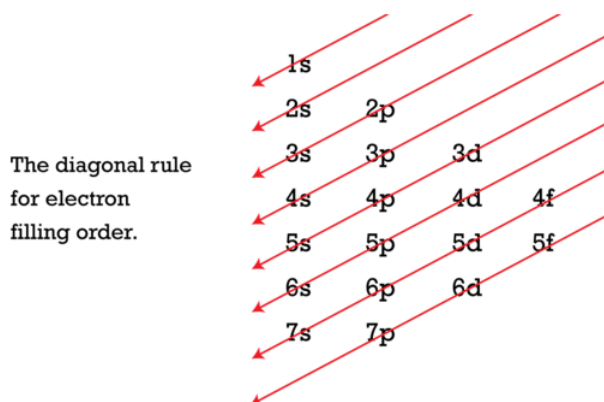


Figure 4.9.3: The Aufbau principle is illustrated in the diagram by following each red arrow in order from top to bottom: $1s$, $2s$, $2p$, $3s$, etc. (Credit: Christopher Auyeung; Source: CK-12 Foundation; License: [CC BY-NC 3.0](https://creativecommons.org/licenses/by-nc/3.0/)(opens in new window))



Summary

- The Aufbau principle gives the order of electron filling in an atom.
- It can be used to describe the locations and energy levels of every electron in a given atom.

Review

1. What is the Aufbau principle?
2. Which orbital is filled after the $2p$?
3. Which orbital is filled after $4s$?
4. Which orbital is filled after $6s$?

This page titled [4.9: Aufbau Principle](#) is shared under a [CK-12](#) license and was authored, remixed, and/or curated by [Theodore Chan](#) via [source content](#) that was edited to the style and standards of the LibreTexts platform.

- **5.15: Aufbau Principle** by [CK-12 Foundation](#) is licensed [CK-12](#). Original source: <https://flexbooks.ck12.org/cbook/ck-12-chemistry-flexbook-2.0/>.