

2.8: Electron Configurations and the Periodic Table

Learning Objectives

- Relate the electron configurations of the elements to the shape of the periodic table.
- Determine the expected electron configuration of an element by its place on the periodic table.

Remember, that the periodic table as a tool for organizing the known chemical elements (Figure 2.8.1). The elements are listed by atomic number (the number of protons in the nucleus), and elements with similar chemical properties are grouped together in columns. Why does the periodic table have the structure it does? The answer is rather simple, if you understand electron configurations: the shape of the periodic table mimics the filling of the subshells with electrons.

The shape of the periodic table mimics the filling of the subshells with electrons.

Let us start with H and He. Their electron configurations are $1s^1$ and $1s^2$, respectively; with He, the $n = 1$ shell is filled. These two elements make up the first row of the periodic table (Figure 2.8.1)

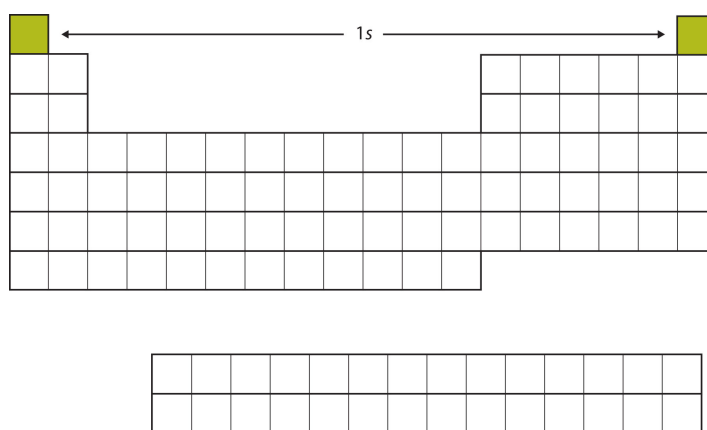


Figure 2.8.1: The 1s Subshell. H and He represent the filling of the 1s subshell.

The next two electrons, for Li and Be, would go into the 2s subshell. Figure 2.8.2 shows that these two elements are adjacent on the periodic table.

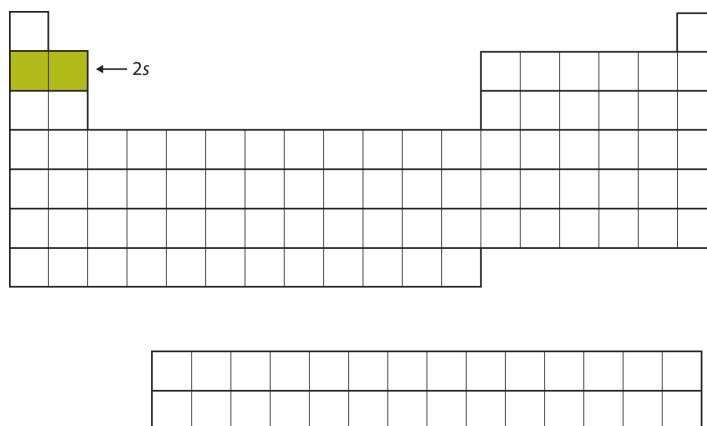


Figure 2.8.2: The 2s Subshell. In Li and Be, the 2s subshell is being filled.

For the next six elements, the $2p$ subshell is being occupied with electrons. On the right side of the periodic table, these six elements (B through Ne) are grouped together (Figure 2.8.3).

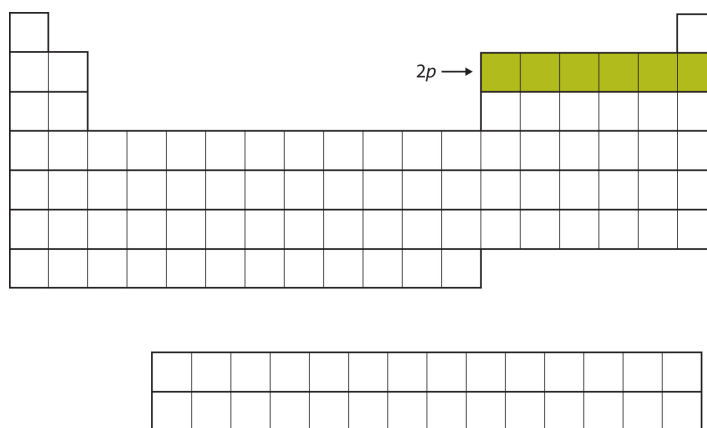


Figure 2.8.3: The 2p Subshell. For B through Ne, the 2p subshell is being occupied.

The next subshell to be filled is the 3s subshell. The elements when this subshell is being filled, Na and Mg, are back on the left side of the periodic table (Figure 2.8.4).

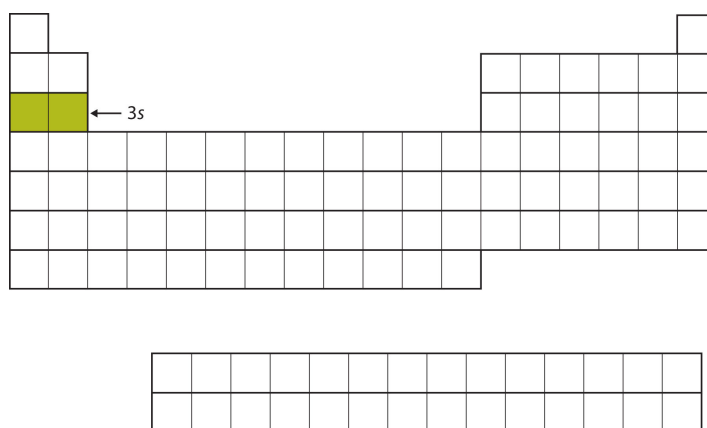


Figure 2.8.4: The 3s Subshell. Now the 3s subshell is being occupied.

Next, the 3p subshell is filled with the next six elements (Figure 2.8.5).

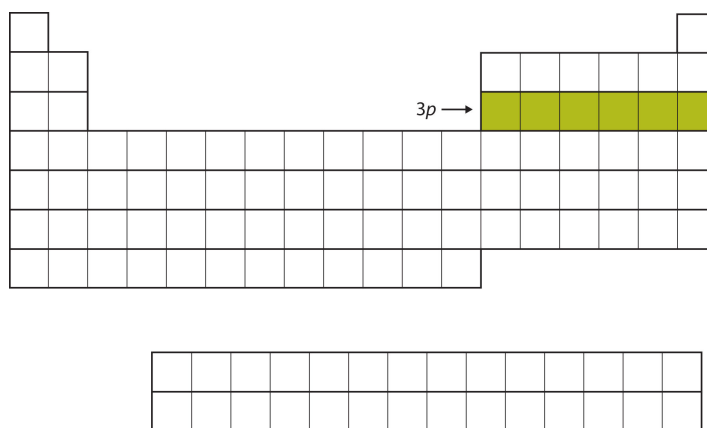


Figure 2.8.5: The 3p Subshell. Next, the 3p subshell is filled with electrons.

Instead of filling the 3d subshell next, electrons go into the 4s subshell (Figure 2.8.6).

The diagram shows a periodic table where the first two columns (s-block) are highlighted in green. An arrow labeled '4s' points to the first column of the fourth row. Below the main table is a separate 2x10 grid representing the d-block, which is currently empty.

Figure 2.8.6: The 4s Subshell. The 4s subshell is filled before the 3d subshell. This is reflected in the structure of the periodic table.

After the 4s subshell is filled, the 3d subshell is filled with up to 10 electrons. This explains the section of 10 elements in the middle of the periodic table (Figure 2.8.7).

The diagram shows a periodic table where the middle section (d-block) is highlighted in green. An arrow labeled '3d' points to the first column of this green section. Below the main table is a separate 2x10 grid representing the f-block, which is currently empty.

Figure 2.8.7: The 3d Subshell. The 3d subshell is filled in the middle section of the periodic table.

And so forth. As we go across the columns of the periodic table, the overall shape of the table outlines how the electrons are occupying the shells and subshells.

The first two columns on the left side of the periodic table are where the s subshells are being occupied. Because of this, the first two rows of the periodic table are labeled the **s block**. Similarly, the **p block** are the right-most six columns of the periodic table, the **d block** is the middle 10 columns of the periodic table, while the **f block** is the 14-column section that is normally depicted as detached from the main body of the periodic table. It could be part of the main body, but then the periodic table would be rather long and cumbersome. Figure 2.8.8 shows the blocks of the periodic table.

The diagram shows a periodic table with four distinct blocks: the s-block (light blue, first two columns), the p-block (red, last six columns), the d-block (green, middle 10 columns), and the f-block (yellow, a separate 2x14 grid at the bottom). Labels 's Block', 'p Block', 'd Block', and 'f Block' are placed near their respective sections.

Figure 2.8.8: Blocks on the Periodic Table. The periodic table is separated into blocks depending on which subshell is being filled for the atoms that belong in that section.

The electrons in the highest-numbered shell, plus any electrons in the last unfilled subshell, are called **valence electrons**; the highest-numbered shell is called the **valence shell**. (The inner electrons are called *core electrons*.) The valence electrons largely control the chemistry of an atom. If we look at just the valence shell's electron configuration, we find that in each column, the valence shell's electron configuration is the same. For example, take the elements in the first column of the periodic table: H, Li, Na, K, Rb, and Cs. Their electron configurations (abbreviated for the larger atoms) are as follows, with the valence shell electron configuration highlighted:

Table shows first column of the periodic table and their electron configurations.

H:	$1s^1$
Li:	$1s^2 2s^1$
Na:	$[\text{Ne}] 3s^1$
K:	$[\text{Ar}] 4s^1$
Rb:	$[\text{Kr}] 5s^1$
Cs:	$[\text{Xe}] 6s^1$

They all have a similar electron configuration in their valence shells: a single s electron. Because much of the chemistry of an element is influenced by valence electrons, we would expect that these elements would have similar chemistry-*and they do*. The organization of electrons in atoms explains not only the shape of the periodic table but also the fact that elements in the same column of the periodic table have similar chemistry.

The same concept applies to the other columns of the periodic table. Elements in each column have the same valence shell electron configurations, and the elements have some similar chemical properties. This is strictly true for all elements in the s and p blocks. In the d and f blocks, because there are exceptions to the order of filling of subshells with electrons, similar valence shells are not absolute in these blocks. However, many similarities do exist in these blocks, so a similarity in chemical properties is expected.

Similarity of valence shell electron configuration implies that we can determine the electron configuration of an atom solely by its position on the periodic table. Consider Se, as shown in Figure 2.8.9. It is in the fourth column of the p block. This means that its electron configuration should end in a p^4 electron configuration. Indeed, the electron configuration of Se is $[\text{Ar}] 4s^2 3d^{10} 4p^4$, as expected.

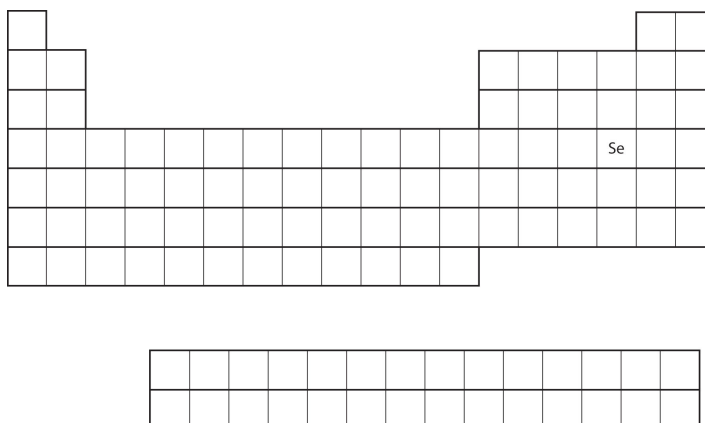


Figure 2.8.9: Selenium on the Periodic Table

✓ Example 2.8.1

From the element's position on the periodic table, predict the valence shell electron configuration for each atom (Figure 2.8.10).

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? Exercise 2.8.2

Using Figure 2.8.2 as your guide, write the electron configuration of the atom that has 20 electrons

Answer

Start at Period 1 of Figure 2.8.2 Place two electrons in the 1s subshell ($1s^2$).

Proceed to Period 2 (left to right direction). Place the next two electrons in the 2s subshell ($2s^2$) and the next six electrons in the 2p subshell ($2p^6$).

Proceed to Period 3 (left to right direction). Place the next two electrons in the 3s subshell ($3s^2$) and the next six electron in the 3p subshell ($3p^6$).

Proceed to Period 4. Place the remaining two electrons in the 4s subshell ($4s^2$).

The electron configuration is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Summary

The arrangement of electrons in atoms is responsible for the shape of the periodic table. Electron configurations can be predicted by the position of an atom on the periodic table

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