

## 3.4: Core and Valence Electrons

### Learning Objectives

- Identify valence electrons using the periodic table and electron configuration.
- Define core and valence electrons.

### Valence Electrons

In the study of chemical reactivity, we will find that the electrons in the outermost principal energy level are very important and so they are given a special name. **Valence electrons** are the electrons in the highest occupied principal energy level of an atom.

In the second period elements, the two electrons in the  $1s$  sublevel are called **inner-shell electrons** and are not involved directly in the element's reactivity or in the formation of compounds. Lithium has a single electron in the second principal energy level and so we say that lithium has one valence electron. Beryllium has two valence electrons. How many valence electrons does boron have? You must recognize that the second principal energy level consists of both the  $2s$  and the  $2p$  sublevels and so the answer is three. In fact, the number of valence electrons goes up by one for each step across a period until the last element is reached. Neon, with its configuration ending in  $2s^2 2p^6$ , has eight valence electrons.

The alkali metal sodium (atomic number 11) has one more electron than the neon atom. This electron must go into the lowest-energy subshell available, the  $3s$  orbital, giving a  $1s^2 2s^2 2p^6 3s^1$  configuration. The electrons occupying the outermost shell orbital(s) (highest value of  $n$ ) are called valence electrons, and those occupying the inner shell orbitals are called **core electrons** (Figure \PageIndex{4}). Since the core electron shells correspond to noble gas electron configurations, we can abbreviate electron configurations by writing the noble gas that matches the core electron configuration, along with the valence electrons in a condensed format. For our sodium example, the symbol  $[\text{Ne}]$  represents core electrons, ( $1s^2 2s^2 2p^6$ ) and our abbreviated or condensed configuration is  $[\text{Ne}]3s^1$ .

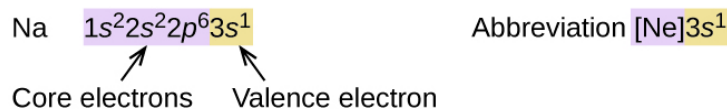
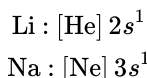


Figure 3.4.1: A core-abbreviated electron configuration (right) replaces the core electrons with the noble gas symbol whose configuration matches the core electron configuration of the other element.

Similarly, the abbreviated configuration of lithium can be represented as  $[\text{He}]2s^1$ , where  $[\text{He}]$  represents the configuration of the helium atom, which is identical to that of the filled inner shell of lithium. Writing the configurations in this way emphasizes the similarity of the configurations of lithium and sodium. Both atoms, which are in the alkali metal family, have only one electron in a valence  $s$  subshell outside a filled set of inner shells.



A chemical reaction results from electron removal, electron addition, or electron sharing of the valence electrons of the different atoms. The path a specific element will take depends on where the electrons are in the atom and how many there are. Thus, it is convenient to separate electrons into two groups. Valence shell electrons (or, more simply, the *valence electrons*) are the electrons in the highest-numbered shell, or valence shell, while core electrons are the electrons in lower-numbered shells. We can see from the electron configuration of a carbon atom— $1s^2 2s^2 2p^2$ —that it has 4 valence electrons ( $2s^2 2p^2$ ) and 2 core electrons ( $1s^2$ ). You will see in the next chapters that the chemical properties of elements are determined by the number of valence electrons.

### ✓ Example 3.4.3

Examine the electron configuration of neutral phosphorus atoms in Example 3.4.1,  $1s^2 2s^2 2p^6 3s^2 3p^3$  and write the abbreviated notation.

#### Solution

Phosphorus has electron configuration,  $1s^2 2s^2 2p^6 3s^2 3p^3$ .

The highest-numbered shell is the third shell ( $3s^23p^3$ ): **2 electrons** in the 3s subshell and **3 electrons** in the 3p subshell. That gives a total of **5 valence electrons**.

The 10 inner shell (core) electrons,  $1s^22s^22p^6$  can be replaced by [Ne] (see Figure 3.4.3). Abbreviated notation is : [Ne] $3s^23p^3$

### ? Exercise 3.4.3

Examine the electron configuration of neutral calcium atom (Exercise 3.4.2),  $1s^22s^22p^63s^23p^64s^2$ , and write the abbreviated notation.

#### Answer

The highest-numbered shell is the fourth shell  $4s^2$ , which has **2 electrons** in the 4s subshell. Hence, Calcium has **2 valence electrons**.

The 18 inner-shell (core) electrons,  $1s^22s^22p^63s^23p^6$ , can be replaced by [Ar], see Figure 3.4.3 The abbreviated notation is: [Ar] $4s^2$

### ✓ Example 3.4.4

Based on their respective locations in the periodic table (use Figure 3.4.3), determine the number of valence electrons and the valence shell configuration of elements A, B and C.

#### Solution

Element A is located in Period 2, the 5th position in 2p-block. Before the electrons are placed in 2p subshell, the 2s subshell must be filled first. This means that A has **two valence electrons** in 2s ( $2s^2$ ) and **five valence electrons** in 2p ( $2p^5$ ). Answer:  $2s^22p^5$ . It has  $2 + 5 = 7$  **valence electrons**.

Element B is located in Period 3, the 2nd position in 3s-block. This means that B has **two valence electrons** in 3s ( $3s^2$ ). Answer:  $3s^2$ .

Element C is located in Period 5, the 1st position in 5s-block). This means that there is only **one valence electron** in 5s ( $5s^1$ ). Answer:  $5s^1$ .

### Exercise

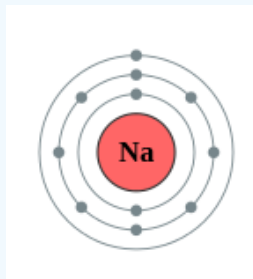
Using the location of Na in the periodic table (Figure 3.4.3), draw the shell diagram of sodium atom.

#### Answer

Sodium (Na) is the first element in the 3rd row (Period 3) in the periodic table. This means that the first shell and second shells of Na atom are filled to the maximum number of electrons.

The first shell (1s) is filled with **2 electrons**. The second shell (2s and 2p) has a **total of 8 electrons**. And, the third (last) shell has **1 electron**.

The shell diagram of the Na atom is shown below. The shell nearest the nucleus (first shell) has 2 electrons (2 dots), the second shell has 8 electrons and the last (outermost) shell has 1 electron. (**2.8.1**)



### Concept Review Exercises

1. What is the difference between core electrons and valence electrons?

### Answers

1. Electrons are organized into shells and subshells around nuclei.
2. The electron configuration states the arrangement of electrons in shells and subshells.
3. Valence electrons are in the highest-numbered shell; all other electrons are core electrons.

### Key Takeaway

- Electrons are organized into shells and subshells about the nucleus of an atom.
- The valence electrons determine the reactivity of an atom.

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