

Valence Electrons

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CONCEPT

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Valence Electrons

Lesson Objectives

The student will:

- define valence electrons.
- indicate the number of valence electrons for selected atoms.
- draw Lewis dot diagrams for selected atoms.

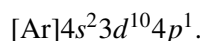
Vocabulary

- core electron
- Lewis dot diagram
- valence electron
- valence shell

Introduction

The electrons in the outermost shell are the **valence electrons**. These are the electrons in an atom that can participate in a chemical reaction. Since filled *d* or *f* subshells are seldom disturbed in a chemical reaction, we can define valence electrons as follows: The electrons in an atom that are not present in the previous noble gas (elements in the last column of the periodic table), ignoring filled *d* or *f* subshells.

Gallium has the following electron configuration:



The *4s* and *4p* electrons can be lost in a chemical reaction, but the electrons in the filled *3d* subshell cannot. Gallium therefore has three valence electrons.

Determining Valence Electrons

Valence electrons are the electrons in the outermost principal quantum level of an atom. Sometimes, the outermost energy level is called the **valence shell**. The electrons that are not in the outermost energy level are known as **core electrons**. The number of valence electrons for an atom can be seen in either the orbital representation or the electron configuration. The electron configuration for magnesium is $1s^22s^22p^63s^2$. The outer energy level for this atom is $n = 3$, and it has two electrons in this energy level. Therefore, magnesium has two valence electrons. The electron configuration for sulfur is $1s^22s^22p^63s^23p^4$. The outer energy level in this atom is $n = 3$. It holds six electrons, so sulfur has six valence electrons. The electron configuration for gallium is $1s^22s^22p^63s^23p^64s^23d^{10}4p^1$. The outer energy level for this atom is $n = 4$, and it contains three electrons. You must recognize that even though the *3d*

sub-level is mixed in among the $4s$ and $4p$ sub-levels, $3d$ is *not* in the outer energy level, so the electrons in the $3d$ sub-level are *not* valence electrons. Gallium has three electrons in the outer energy level and therefore has three valence electrons. The identification of valence electrons is vital because the chemical behavior of an element is determined primarily by the arrangement of the electrons in the valence shell.

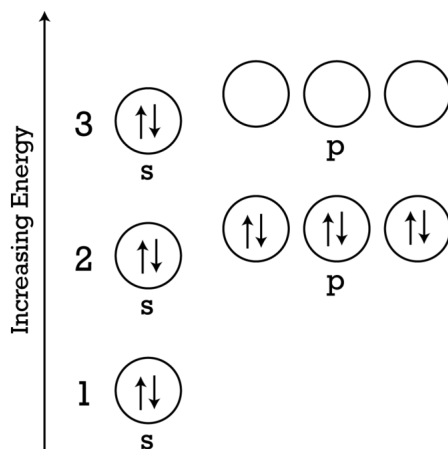
Lewis Dot Diagrams

We can represent the valence electrons of an atom using a **Lewis dot diagram**. A Lewis dot diagram indicates valence electrons as dots around the symbol of the element. A Lewis dot diagram, also known as an electron dot diagram, consists of two parts: the elemental symbol, which represents the core (inner electrons and nucleus), and a group of dots. There can be between 1 through 8 dots, with each dot representing a valence electron.

The electron configuration for sodium (Na) is: $1s^2 2s^2 2p^6 3s^1$. The core electrons are $1s^2 2s^2 2p^6$. The valence electron is $3s^1$. To draw a Lewis electron dot diagram for sodium, you can picture the symbol for sodium in a box with four sides. Each side of the box represents either the s or one of the three p orbitals in the outermost energy level of the atom. The first and second valence electrons are placed on the side representing the s orbital, and the next electrons are placed in the p orbitals. The electron dot diagram also follows Hund's rule, so all the p orbitals in the diagram must contain at least one electron before any of the p orbitals can have a second electron. Since each side can only have two electrons, there can be a maximum of $2 \times 4 = 8$ electrons on any Lewis electron dot diagram. For sodium, a single dot will represent its one valence electron. Thus, the Lewis dot formula for sodium is:



Look at the electron configuration for magnesium shown below. Magnesium is the twelfth element on the periodic table.

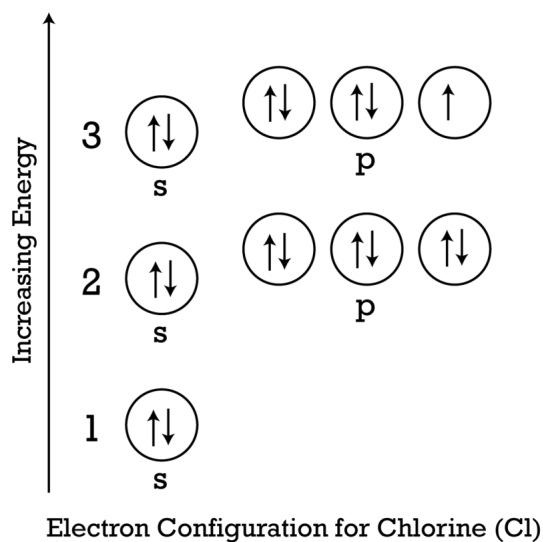


Electron Configuration for Magnesium (Mg)

To draw the Lewis electron dot diagram, picture the symbol for magnesium in a box, which represents all of the core electrons ($1s^2 2s^2 2p^6$). Then, place the valence electrons around the sides of the box with each side representing an orbital in the outermost energy level. How many valence electrons does magnesium have? There are 2 valence electrons, as indicated by $3s^2$. Therefore, the Lewis electron dot formula for magnesium is:



Look at the electron configuration for chlorine.



The electron configuration for chlorine (Cl) could be written as: $1s^2 2s^2 2p^6 3s^2 3p^5$. The core electrons would be $1s^2 2s^2 2p^6$, while the valence electrons would be in the third shell (or where $n = 3$). Therefore, chlorine has 7 valence electrons. The Lewis electron dot diagram would look like the following:



Example:

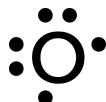
Write the Lewis electron dot formula for:

1. Oxygen
2. Sulfur
3. Potassium
4. Carbon

Solution:

1. Oxygen has the electron configuration: $1s^2 2s^2 2p^4$

The Lewis electron dot formula is:



2. Sulfur has the electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^4$

The Lewis electron dot formula is:



3. Potassium has the electron configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

The Lewis electron dot formula is:



4. Carbon has the electron configuration: $1s^2 2s^2 2p^2$

The Lewis electron dot formula is:

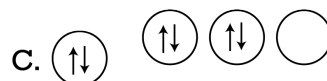
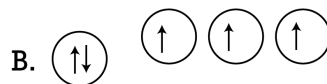
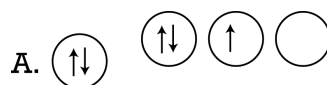


Lesson Summary

- Valence electrons are the electrons in the outermost principal quantum level of an atom.
- The identification of valence electrons is vital because the chemical behavior of an element is determined primarily by the arrangement of the electrons in the valence shell.
- In a Lewis dot diagram, the chemical symbol is surrounded by a number of dots. Each dot represents a valence electron.

Review Questions

1. How many valence electrons are present in the following electron configuration code?
 - a. $1s^2 2s^2 2p^6 3s^2 3p^3$
 - b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$
2. How many valence electrons does magnesium have?
3. How many valence electrons does oxygen have?
4. Which of the following is the correct orbital representation for the valence shell of phosphorus?



D. None of these.

5. What is the maximum number of dots in a Lewis dot diagram?
6. Draw the Lewis dot diagram for lithium.
7. Draw the Lewis dot diagram for calcium.

8. Draw the Lewis dot diagram for bromine.
9. Draw the Lewis dot diagram for selenium.

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