12.13: The Aufbau Principles and the Periodic Table

Aufbau comes from the German word "Aufbauen" which means "to build". In essence when writing electron configurations we are building up electron orbitals as we proceed from atom to atom. As we write the electron configuration for an atom, we will fill the orbitals in order of increasing atomic number. The Aufbau principle originates from the Pauli's exclusion principle which says that no two *fermions* (e.g., electrons) in an atom can have the same set of quantum numbers, hence they have to "pile up" or "build up" into higher energy levels. How the electrons build up is a topic of electron configurations.

Example 12.13.1

If we follow the pattern across a period from B (Z=5) to Ne (Z=10) the number of electrons increase and the subshells are filled. Here we are focusing on the p subshell in which as we move towards Ne, the p subshell becomes filled.

- B (Z=5) configuration: $1s^2\ 2s^2\ 2p^1$
- C (Z=6) configuration: $1s^2\ 2s^2\ 2p^2$
- N (Z=7) configuration: $1s^2\ 2s^2\ 2p^3$
- O (Z=8) configuration: $1s^2\ 2s^2\ 2p^4$
- F (Z=9) configuration: $1s^2\ 2s^2\ 2p^5$
- Ne (Z=10) configuration: $1s^2\ 2s^2\ 2p^6$

Electron configuration can be described as how electrons are assembled within the orbitals shells and subshells of an atom. It is important to understand what an electron is in order to fully understand the electron configuration. An electron is a sub atomic particle that is associated with a negative charge. Electrons are found outside of the nucleus, as opposed to neutrons (particles with neutral charge,) and protons (particles with positive charge.) Furthermore, electrons are associated with energy, more specifically quantum energy, and exemplify wave-like and particle-like characteristics. The word configuration simply means the arrangement of something. Therefore electron configuration in straightforward language means the arrangement of electrons.

Introduction

In general when filling up the electron diagram, it is customary to fill the lowest energies first and work your way up to the higher energies. Principles and rules such as the Pauli exclusion principle, Hund's rule, and the Aufbau process are used to determine how to properly configure electrons. The Pauli exclusion rule basically says that at most, 2 electrons are allowed to be in the same orbital. Hund's rule explains that each orbital in the subshell must be occupied with one single electron first before two electrons can be in the same orbital. Lastly, the Aufbau process describes the process of adding electron configuration to each individualized element in the periodic table. Fully understanding the principles relating to electron configuration will promote a better understanding of how to design them and give us a better understanding of each element in the periodic table. How the periodic table was formed has an intimate correlation with electron configuration. After studying the relationship between electron configuration and the period table, it was pointed out by Niels Bohr that electron configurations are similar for elements within the same group in the periodic table. Groups occupy the vertical rows as opposed to a period which is the horizontal rows in the table of elements.

S, P, D, and F Blocks

- It is easy to see how similar electron configurations are in a group when written out. (Allow "n" to be the principal quantum number.) Lets first take a look at group 1 atoms. Group 1 atoms are the alkali metals. Let n=1. Notice the similar configuration within all the group 1 elements.

Group	Element	Configuration
1	H	$1s^1$
1	Li	$[He]2s^1$
1	Na	$[Ne]3s^1$
1	K	$[Ar]4s^1$
1	Rb	$[Kr]5s^1$

1	Cs	$[Xe]6s^1$
1	Fr	$[Rn]7s^1$

Now consider group 16 elements. These elements also will also have similar electron configurations to each another because they are in the same group; these elements have 6 valence electrons.

Group	**Element**	**Configuration**
16	O	$[He]2s^22p^4$
16	S	$[Ne]3s^23p^4$
16	Se	$[Ar]3d^{10}4s^2\ 4p^4$
16	Te	$[Kr]4d^{10}5s^2\ 5p^4$
16	Po	$[Xe]4f^{14}\ 5d^{10}6s^2\ 6p^4$

Outside links

- 1. Question, True or False: Elements in the same period have similar electron configurations.

  Answer: False. Elements in the same GROUP have similar electron configurations.

  2. Question: What element has the electron configuration $[Ar]\ 4s^2\ 3d^{10}\ 4p^5$?

  Answer: Bromine

  3. Question: What element has the electron configuration $[Xe]\ 4f^{14}\ 5d^{10}\ 6s^2\ 6p^{3?}$

  Answer: Bismuth

  4. Question: Demonstrate how elements in a group share similar characteristics by filling in the electron configurations for the Group 18 elements:

Group	Element	Configuration
18	He	
18	Ne	
18	Ar	
18	Kr	
18	Xe	
18	Rn	

  Answer: $1s^2$, $[He]2s^22p^6$, $[Ne]3s^23p^6$, $[Ar]3d^{10}4s^24p^6$, $[Kr]4d^{10}5s^25p^6$, $[Xe]4f^{14}5d^{10}6s^26p^6$

  5. Question: How many valence electrons are there in Iodine?

  Answer: Iodine, z=53, group 17. This means there are seven valence electrons.

  6. Question: What is the highest number of electrons a 4p subshell can hold?

  Answer: 6! Each 3 p orbital can hold 2 electrons so if they are all filled, the answer is 6. You get this by multiplying the three orbitals by 2 electrons per orbital, so 3 multiplied by 2 equals 6.

  Make up some practice problems for the future readers.

  ### Contributors and Attributions

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