Supplemental Activities

Module: Atomic Theory

Section: Electron Configurations of Many Electron Atoms - Key

Rules and Quantum Numbers

Activity 1

1. Match each idea on the left with the appropriate explanation or definition:

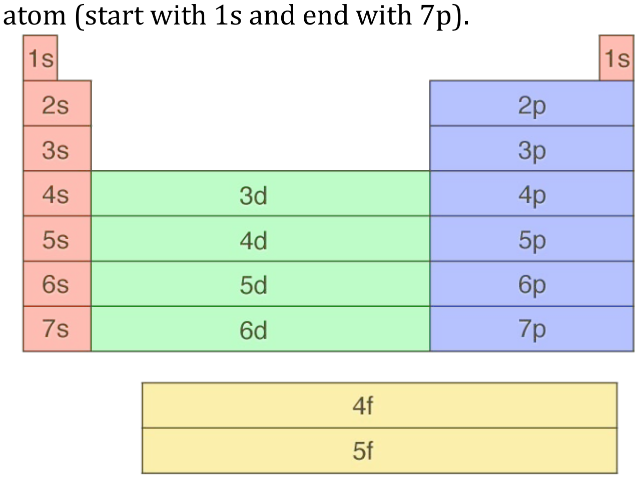
__b.__ Pauli Exclusion Principle	a. electrons must be placed in separate degenerate orbitals first before pairing.
__a.__ Hund's Rule	b. requires the use of m_s as the fourth quantum number.
__c.__ Aufbau principle	c. electron configurations in the ground state are built up from the lowest energy levels to higher energy levels.

2. The fourth quantum number, m_s , can have the value of +½ or –½. Orbitals hold up to two electrons and because of the Pauli Exclusion principle a fourth quantum number is needed.

3. Within multi-electron atoms, the fact that the 2s orbital is lower in energy than the 2p orbitals is called a "loss of degeneracy within energy levels."

Activity 2

1. Identify the s, p, d and f blocks on the periodic table and write the order in which they are filled for a ground state atom (start with 1s and end with 7p).



http://ch301.cm.utexas.edu/atomic/index.php#e-config/aufbau-principle.html

1s → 2s → 2p → 3s → 3p → 4s → 3d → 4p → 5s → 4d → 5p → 6s → 4f → 5d → 6p → 7s → 5f → 6d → 7p

2. The orbital notation of the electron configuration of cesium is $1s^{2}2s^{2}2p^{6}3s^{2}3p^{6}4s^{2}3d^{10}4p^{6}5s^{2}4d^{10}5p^{6}6s^{2}$. Without looking at the periodic table, we know that cesium is in the 6th row and in the s block.

Ground State Electron Configurations

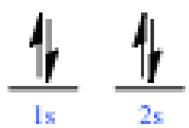
Activity 1

1. Write the ground state electron configuration for the following elements in three ways: the full electron configuration, the shorthand electron configuration and the orbital notation with the arrows.
   i. Beryllium

      Full: $1s^{2}2s^{2}$

      Shorthand: [He]$2s^{2}$

      Orbital Notation:

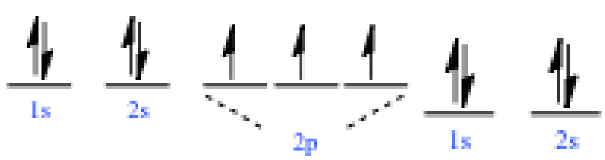


   ii. Nitrogen

      Full: $1s^{2}2s^{2}2p^{3}$

      Shorthand: [He]$2s^{2}2p^{3}$

      Orbital Notation:

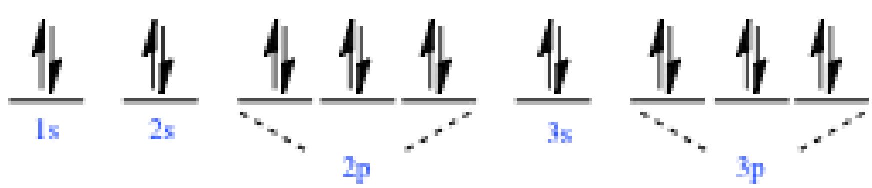


   iii. Argon

      Full: $1s^{2}2s^{2}2p^{6}3s^{2}3p^{6}$

      Shorthand: [Ar]

      Orbital Notation:



2. Differentiate between the terms “subshell” and “orbital.”
A subshell refers to the *type* of orbital: s, p, d or f and can be determined from the quantum number l. Within a subshell there can be one (s), three (p), five (d) or seven (f) orbitals. The quantum number m_l tells us in which exact orbital an electron is residing.

Activity 2

1. Write the ground state electron configuration for the following elements in three ways: the full ground state electron configuration, the shorthand electron configuration and the orbital notation with the arrows.
   a. Iodine
   Full: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$

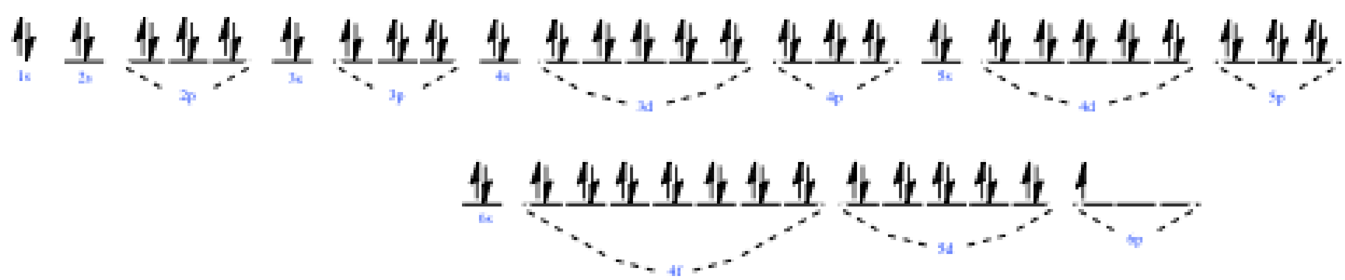
   Shorthand: [Kr] $5s^2 4d^{10} 5p^5$

   Orbital Notation:

   b. Thallium
   Full: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^1$

   Shorthand: [Xe]$6s^2 4f^{14} 5d^{10} 6p^1$

   Orbital Notation:



2. Write a list of all the possible quantum numbers for an electron in a 4f subshell of bismuth (Bi).

   n = 4 (fourth energy level)

   l = 3 (in the f orbital)

   m_l = −3, −2, −1, 0, 1, 2, 3 (m_l can range from −l to +l, so seven possibilities)
   m_s = −½, +½ (m_s is either −½ or +½)

   There are fourteen unique sets of quantum numbers available to describe an electron found in a 3d orbital of Gallium:

(4, 3, −3, −½) ; (4, 3, −3, +½) ; (4, 3, −2, −½) ; (4, 3, −2, +½) ; (4, 3, −1, −½) ;

(4, 3, −1, +½) ; (4, 3, 0, −½) ; (4, 3, 0, +½) ; (4, 3, 1, −½) ; (4, 3, 1, +½) ;

(4, 3, 2, −½) ; (4, 3, 2, +½) ; (4, 3, 3, −½) ; (4, 3, 3, +½)

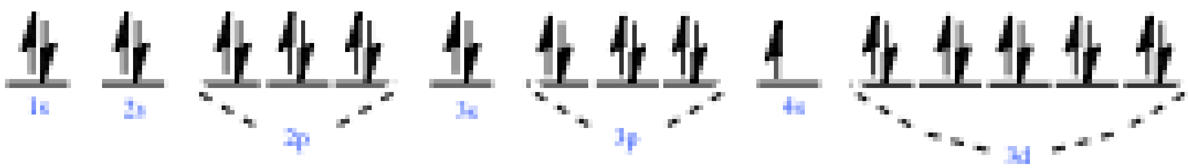
Activity 3

1. Exceptions to ground state electron configurations occur in the d and f blocks when an atom is one electron shy of a half–filled or fully or completely filled subshell.

2. Write the ground state electron configuration for the following elements in three ways: the full ground state electron configuration, shorthand electron configuration and the orbital notation with the arrows.
   a. Copper
   Full: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

   Shorthand:$[Ar]4s^1 3d^{10}$

   Orbital Notation:



   b. Molybdenum
   Full: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^5$

   Shorthand: $[Kr]5s^1 4d^5$

   Orbital Notation:

Activity 4

1. Differentiate between the terms “core” and “valence.”

Core refers to the electrons that are between the nucleus and the electrons in the highest energy level. Those electrons in the highest energy level are the valence electrons.

2. The shell model of an atom is sometimes referred to as the "planetary model." Explain why you think people use this nickname and explain what the sun and planets correspond to in the shell model.

   In the shell model the electrons orbit around the nucleus in fixed energy levels. In a similar way, planets orbit a star in predictable orbits. The sun corresponds to the nucleus of an atom in the shell model and the planets correspond to the electrons in orbit around the nucleus. However, there can be many electrons in the same energy shell unlike planetary systems (that we have observed) where a single planet dominates an orbit (smaller moons and asteroids might move in connection to this orbiting planet).