Exercise 7.11

Electron Configurations

Name: ____________________________

Date:_________________ Per:________

Each electron in an atom is described by four different **quantum numbers**. The first three (*n*, ℓ, *m*) specify the orbital of interest, and the fourth (*s*) specifies the spin of the electron.

1. **Principal Quantum Number (n):** (*n = 1, 2, 3, etc.*)
   - *n* = the **energy level** (shell) of the electron.
   - The total number of orbitals for a given *n* value is n^2.
2. **Sublevel (Angular Momentum Quantum Number) (ℓ):** (ℓ = 0, ..., *n*-1)
   - ℓ = the **shape** of an orbital (*s, p, d, f*) → [***s* = 0, *p* = 1, *d* = 2, *f* = 3, *g* = 4, *h* = 5...**]
   - The energy of the subshell increases with ℓ (s < p < d < f).
3. **Magnetic Quantum Number (*m*):** (*m* = - ℓ, ..., 0, ..., + ℓ)
   - *m* = the individual **orbital** which hold the electrons.
   - There are 2 ℓ +1 orbitals in each subshell. The *s* subshell has only one orbital, the *p* subshell has three orbitals…
4. **Spin Quantum Number (*s*):** (*s* = +½ or -½)
   - *s* = the **spin** axis of an electron.
   - An electron can spin in only one of two directions (sometimes called *up* and *down*).

The **Pauli exclusion principle** states that *no two electrons in the same atom can have identical values for all four of their quantum numbers*. No more than two electrons can occupy the same orbital, and that two electrons in the same orbital must have opposite spins. Because an electron spins, it creates a magnetic field, which can be oriented in one of two directions. For two electrons in the same orbital, the spins must be opposite to each other; the spins are said to be paired. These substances are not attracted to magnets and are said to be diamagnetic. Atoms with more electrons that spin in one direction than another contain unpaired electrons. These substances *are* weakly attracted to magnets and are said to be paramagnetic.

DIRECTIONS: *Fill in the orbital notation (arrows) below, then write the four quantum numbers which describe the location of the highest energy (last) electron of the following elements:*

Element	1s	2s	2p			3s	3p			4s	3d					4p			Quantum Numbers
1. Al																			
2. Ne																			
3. P																			
4. Fe																			
5. Mg																			
6. As																			

DIRECTIONS: *Give the four quantum numbers which describe the location of each of the following:*

7. The 4th electron in carbon ____
8. The 25th electron in Mn ____
9. The 57th electron in Ho ____
10. The 49th electron in Xe ____

DIRECTIONS: *Identify the element whose highest energy electron would have the following four quantum numbers:*

11. 3, 1, -1, +1/2 ____
12. 4, 2, +1, +1/2____
13. 6, 1, 0, -1/2 ____
14. 4, 3, +3, -1/2 ____
15. 2, 1, +1, -1/2____

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In 1926 Schrodinger showed that electrons in a hydrogen atom could be described by a **wave function, Ψ**. Electrons are often described as being in **orbitals** around an atom that are mathematical "constructs" based on the wave function, **Ψ**, that describes the motion of an electron.

An orbital is, more correctly, a mathematical function, **$4pr^2\Psi^2$**, that describes the region of high probability in 3D space, around a nucleus, where an electron may be found. Orbitals are commonly represented by the boundary surfaces that encloses the region where there is a 90-95 % probability of finding the electron.

These regions of space, or orbitals, collectively create a region with fuzzy boundaries like a cloud. That cloud can be subdivided into energy levels *(1-7 typically)*, which can be subdivided into sublevels *(s,p,d,f)*, and finally into orbitals. Each orbital may hold up to two electrons. This distribution of electrons can be described using models of the electron cloud: box orbital notations, electron configurations, Bohr models, and Lewis dot models.

DIRECTIONS: Write each of the following rules in your own words.

Aufbau Principle: ____

____

Hund's Rule: ____

____

Pauli Exclusion Principle: ____

____

DIRECTIONS: Answer the following in the space provided:

1. What did Bohr mean when stating that the energy of electrons must be quantized? ____________________________

   ____

2. Circle all the orbital destinations that are theoretically possible.

   a. 7s b. 1p c. 5d d. 2d e. 4f f. 6i

3. Circle all the electron configurations that are ruled out by the Pauli Exclusion Principle.

   a. $1s^22s^22p^7$ b. $1s^22s^22p^63s^3$ c. $1s^22s^22p^63s^23p^64s^23d^{12}$ d. $1s^22s^22p^63s^23p^6$

4. Place the following orbitals in order of increasing energy: 1s, 3s, 4s, 6s, 3d, 4f, 3p, 7s, 5d, 5p

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____ 9. _____ 10. _____

DIRECTIONS: Complete the box orbital diagram and electron configuration for each of the following:

5. Manganese (Mn)

Box Orbital   Electron Configuration: ______________________

1s	2s	2p			3s	3p			4s	3d					4p			5s	4d				

6. Nitrogen (N)

Box Orbital   Electron Configuration: ______________________

1s	2s	2p			3s	3p			4s	3d					4p			5s	4d				

7. Argon (Ar)

Box Orbital   Electron Configuration: ______________________

1s	2s	2p			3s	3p			4s	3d					4p			5s	4d				

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8. Arsenic (As)

Box Orbital — Electron Configuration: ______________________

1s	2s	2p			3s	3p			4s	3d					4p			5s	4d				

9. Copper (Cu)

Box Orbital — Electron Configuration: ______________________

1s	2s	2p			3s	3p			4s	3d					4p			5s	4d				

10. Silver (Ag)

Box Orbital — Electron Configuration: ______________________

1s	2s	2p			3s	3p			4s	3d					4p			5s	4d				

11. Write the <u>complete</u> electron configuration for the following elements:

a. Cl ______________________________ d. K ______________________________

b. Kr ______________________________ e. Li ______________________________

c. Sc ______________________________ f. Sn ______________________________

12. Write the <u>condensed</u> electron configuration for the following elements:

a. He ______________________________ d. V ______________________________

b. Ni ______________________________ e. Au ______________________________

c. Br ______________________________ f. I ______________________________

13. Which set(s) of quantum numbers are unacceptable? ______________________

a. n=3, l= -2, m_l= 0, m_s= +½ b. n=2, l= 2, m_l= -1, m_s= -½ c. n=6, l= 2, m_l= -2, m_s= +½

14. Write the quantum numbers for the **shaded** electron in the following diagrams:

a. 3p orbitals [↑↓][↑↓][↑] _______________ c. 4d orbitals [↑↓][↑↓][↑↓][↑↓][↑↓] _______________

b. 5s orbital [↑↓] _______________ d. 3d orbitals [↑↓][↑][↑][↑][↑] _______________

15. What element is it whose neutral, isolated atom has two valence electrons in the 5s subshell and four electrons in the 5p subshell?

16. Which electron configuration(s) is/are those of an atom in the <u>excited</u> state? _________________________

a. $1s^2\ 2s^1$ d. $1s^2\ 2s^1\ 2p^2$

b. $1s^2\ 2s^2\ 2p^1$ e. $[Ar]\ 3d^8$

c. $1s^2\ 2s^1\ 3d^6$

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17. How many filled 3p orbitals are there in a neutral atom of cobalt? ________________________

18. Given the following electron configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 5s^2\ 4d^{10}\ 5p^6\ 6s^2\ 4f^{14}\ 5d^{10}\ 6p^4$,

    a. In which **sublevel** are the electrons of highest energy located? ___________________________

    b. What is the correct chemical symbol for neutral element above? ______________________________

    c. What is the number of electron pairs in the 5d orbital? _____________________________

    d. This element would most likely be classified as what type of element? _____________________________

    e. The correct number of outer shell electrons for this element is how many? __________________________

    f. This element is radioactive - true or false? ______________________________

    g. How many sublevels are either filled or partially filled? ____________________________

    h. An orbital is labeled by the magnetic quantum number, *m* = +2:

       This could not be found in which subshell(s)? ___________________________

19. Explain why the following ground-state electron configurations are not possible:

    a. $1s^2 2s^3 2p^3$ ____

    b. $1s^2 2s^2 2p^3 3s^6$ ____

    c. $1s^2 2s^2 2p^7 3s^2 3p^8$ ____

    d. $1s^2 2s^2 2p^6 3s^2 3p^1 4s^2 3d^{14}$ ____