Chemistry H

Exercise 4.2a
Quantum Numbers

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 <u>paired</u>. These substances are not attracted to magnets and are said to be <u>diamagnetic</u>. Atoms with more electrons that spin in one direction than another contain <u>unpaired</u> electrons. These substances *are* weakly attracted to magnets and are said to be <u>paramagnetic</u>.

1. Draw the shapes of the sub−levels listed below.

1s	***p***	***d***
2s		

2. Give the *n* and ℓ values for the following orbitals:

a. 1s _____
b. 3s _____
c. 2p _____
d. 4s _____
e. 3p _____
f. 4d _____
g. 5p _____
h. 5f _____

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DIRECTIONS: *Write the quantum numbers for the electrons shown in bold.*

	1s	2s	2p			3s	3p			4s	3d					4p			
n	1	2				3				4	3					4			
ℓ	0	0	1			0	1			0	2					1			
m	0	0	−1	0	+1	0	−1	0	+1	0	−2	−1	0	+1	+2	−1	0	+1	Quantum Numbers
3.	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	**↑**	↑	↑						
4.	↑↓	↑↓	↑↓	↑↓	↑↓	**↑↓**	↑↓	↑↓	↑↓	↑↓	↑	↑	↑	↑					
5.	↑↓	↑↓	↑↓	**↑↓**	↑↓	↑↓	↑	↑											
6.	↑↓	**↑↓**	↑↓	↑↓	↑↓	↑													
7.	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	**↑**	↑		
8.	↑↓	↑↓	↑↓	↑↓	↑↓	**↑↓**	↑↓	↑↓	↑↓	↑↓	↑								

9. Circle any sets of quantum numbers that are unacceptable?

   a. $n = 3$, $\ell = -2$, m = 0, $s = +½$

   b. $n = 2$, $\ell = 2$, m = –1, $s = –½$

   c. $n = 6$, $\ell = 2$, m = –2, $s = +½$

   d. $n = 1$, $\ell = 0$, m = −1, $s = –½$

   e. $n = 4$, $\ell = 2$, m = −2, $s = +½$

   f. $n = 3$, $\ell = 3$, m = 0, $s = –½$

10. Circle any of the following that represent impossible combinations of *n* and ℓ:

    a. 1p

    b. 4s

    c. 5f

    d. 2d

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

11. 3, 1, -1, +1/2 _____

12. 3, 2, +1, +1/2 _____

13. 2, 1, 0, -1/2 _____

14. 3, 2, -1, -1/2 _____

15. 2, 1, +1, -1/2 _____