Quantum Number

1. Principal Quantum Number

   a. Is represented by – n

   b. Has values from ranging from – 1 → ∞

   c. Indicates – the size and energy level in which the electron is housed. The bigger the n value, the further the electro is from the nucleus.

      i. Degeneracy is when orbitals have the same value of n.

2. Angular Momentum Quantum Number

   a. Is represented by – l

   b. Has values from ranging from – 0 → (n-1)

   c. Indicates – the type of orbital.

      i. $l = 0$ → s orbital

      ii. $l = 1$ → p orbital

      iii. $l = 2$ → d orbital

      iv. $l = 3$ → f orbital

3. Magnetic Quantum Number

a. Is represented by – m_l

b. Has values from ranging from – $(-l \rightarrow +l)$

c. Indicates – # of orbitals.

i. $l = 0$ (the s orbital) $\rightarrow$ $m_l = 0$
This means that there is only one s-orbital.

ii. $l = 1$ (the p orbital) $\rightarrow$ $m_l = (-1, 0, +1)$
Because there are 3 values of for m_l, there would be three p orbitals. Ultimately, these correspond to different orientations these orbitals can have in three dimensional space. In the case of the p orbital we call them p_x, p_y, and p_z.

iii. $l = 2$ (the d orbital) $\rightarrow$ $m_l = (-2, -1, 0, 1, 2)$
Because there are 5 values for m_l there would be five differently orientated d orbitals. Labeled d_{xz}, d_{xy}, d_{yz}, d_{z^2} and $d_{x^2 - y^2}$

iv. $l = 3$ (the f orbital) $\rightarrow$ $m_l = (-3, -2, -1, 0, 1, 2, 3)$
Because there are 7 values for m_l there would be seven differently orientated f orbitals.

4. Spin Quantum Number

a. Is represented by – m_s

b. Has values from ranging from – (+½, - ½)

c. Indicates – spin of an electron

5. What is the Pauli Exclusion Principle?

Only 2 electrons can be in a particular orbital and they must have opposite spin numbers.
i.e. no 2 electrons can have the same 4 quantum numbers. They can have the same n, l,and m_l but not the same m_s.

Think of the quantum numbers as assigning an "address" to each electron in an atom. Each successive quantum numbers having a greater specificity. n = street, l= building, m_l=apartment number, m_s= top bunk or bottom bunk (only one to a bunk!)

6. Which of the following pairing of quantum numbers is invalid, why?

a. $n=3$, $l=2$, $m_l=2$, $m_s = ½$

This set of quantum numbers is valid. All values fit the required parameters.

b. $n=4$, $l=3$, $m_l=4$, $m_s =- ½$

This set is invalid. The value of m_l cannot equal 4 if $l = 3$. The maximum value m_l can be is +3.

c. $n=0$, $l=0$, $m_l=0$, $m_s = -½$

This is an invalid set of quantum numbers because n cannot equal zero. It's smallest value is 1.

d. $n=2$, $l=-1$, $m_l=1$, $m_s = ½$

This is an invalid set of quantum numbers because l cannot equal -1. Its lowest value is zero.

7. How many electrons can have the following designation?

When doing these problems it is obviously important to be able to decipher what this type of notation indicates, let's take a look at $2p_x$ as an example.

$2p_x$

n = 2
p = l value (which is 1 for p)
m_l = x

So in this case 3 of the four quantum numbers have been specified. There is only the magnetic spin number remaining. This means that there are only 2 electrons that could have this designation. One would have + ½ and the other –½ as their final quantum number.

a. 1p

So break this down to what each value, that was given, relates to.
n = 1 and p = 1

It is important to take a pause here and determine whether a value of 1 for l is possible if n=1. We realize that it is not. The maximum value for l when n = 1 is zero. Thus the answer to this question is that there are no electrons that could have this designation.

b. $6d_{xy}$

In this case we know that n = 6, l = 2 and m_l = xy. If n = 6, it is completely okay that $l = 2$. This is, therefore, a valid orbital designation. If we consider now, that 3 of the 4 quantum numbers have been specified – we realize that there are only 2 electrons that can have this "address" one with the + ½ spin and one with a – ½ spin.

c. 4f

In this case n = 4 and l = f = 3.
This means that there are 2 quantum numbers remaining to be specified. So now what we want is to consider the number of orbitals contained within f. Based on previous calculations we determined that there were seven f orbitals. Remember that we can determine this by looking at the number of m_l values that correspond to $l = 3$.

Lastly we consider our final quantum number, m_s, which tells us that there are two allowable electrons per orbital.

Giving us: $7 \times 2 = 14e^-$
So, 14 electrons could have the designation 4f.

d. n=3

For this particular problem, only n has been specified. So we need to figure out which orbitals and the number of each orbital type are available when n = 3.

When:

n = 3

l = (0, 1, 2) or s, p, d

Let's now add up the number of orbitals associated with s, p and d.
s = 1 p = 3 d = 5

1+3+5 = 9 total orbitals (each of which can house 2 electrons)

9 x 2 e^- = 18e^-