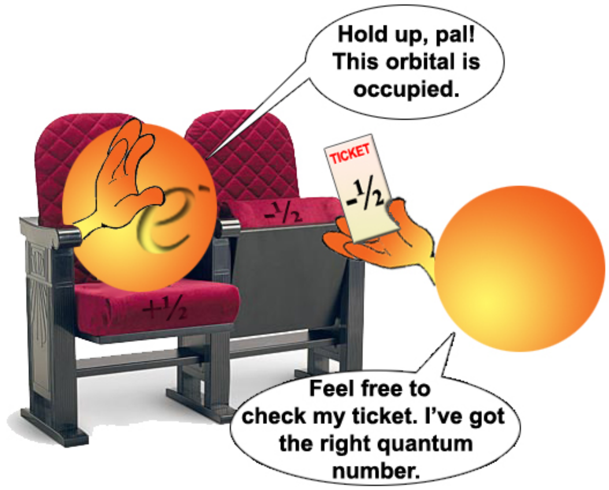
Chemistry: Form WS2.2.5A Name ____________________

ATOMS Date ____________ Period ____

Quantum Numbers



Orbitals are characterized by a series of quantum numbers that describe them. The **principal** quantum number, *n*, or energy level is similar to the shells of the Bohr model. The principal quantum number has integral values from 1 through 7. These correspond to the period numbers in periodic table, and are related to the size and energy of the orbital. As *n* increases, the orbital becomes larger, and the electron spends more time further away from the nucleus. As a result, the electron is less tightly bound to the nucleus and has higher energy. The **angular momentum** quantum number (ℓ) corresponds to the subshells, divisions of principal energy levels. Angular momentum relates to the shape of the orbitals. For example, an orbital with an angular momentum of $\ell = 0$ has no nodes (areas of zero probability of finding an electron within an orbital) and looks spherical, while an orbital with an angular momentum of $\ell = 1$ has one node and looks like a figure eight. Angular momentum has integral values from 0 to *n*–1. As a result the maximum number of subshells in a principal energy level is *n*. None of the existing elements uses more than 4 subshells even in principal energy levels 4 through 7. Subshells are designated by letters: $\ell = 0$ is called *s*, $\ell = 1$ is called *p*, $\ell = 2$ is called *d*, and $\ell = 3$ is called *f*. The subshells in increasing order of energy are *s*, *p*, *d*, and *f*. The energy of an electron can be described by its principal energy level and its subshell. The first principal energy level has one subshell, 1*s*. The second principal energy level has two subshells, 2*s* and 2*p*. The third principal energy level has three subshells, 3*s*, 3*p*, and 3*d*. The fourth principal energy level has four subshells, 4*s*, 4*p*, 4*d*, and 4*f*. The **magnetic** quantum number (m_ℓ)has integral values between ℓ and $-\ell$ including 0. The value of m_ℓ is related to the orientation of the orbital in space relative to the other orbitals of the atom. Spectral data indicate that electrons have a magnetic moment or *spin* with two possible orientations when placed in an external magnetic field. The **electron spin** quantum number (m_s) can have only one of two values, +½, or –½. Wolfgang Pauli concluded, in a given atom, no two electrons can have the same four quantum numbers (**the Pauli Exclusion Principle**). Any electrons in the same orbital will have the same principal quantum number (*n*), the same angular momentum (ℓ), and the same magnetic quantum number (m_ℓ). By the Pauli exclusion principal, they must have different spins to occupy the same orbital. Since there are only two spins, the maximum number of electrons in an orbital is 2.

Answer the questions below based on your knowledge of the reading above, and on your knowledge of chemistry.

1. What are the quantum numbers for the valence electrons of calcium? ____________________
2. For a *d* sublevel:
   a. What is the angular momentum quantum number? ____________________
   b. How many nodes do the orbitals have? ____________________
   c. What are the possible magnetic quantum numbers? ____________________
   d. How many *d* orbitals are there? ____________________
   e. What are the possible electron spin quantum numbers for *d* electrons? ____________________
   f. What is the maximum number of *d* electrons? ____________________