Chem 115 notes
4/15/08

The Game of Quantum Numbers

Degenerate = all having same energy

l		orbital
0	=	s
1	=	p
2	=	d
3	=	f

$m_l = 0 \rightarrow \pm l$

if $l = 1$ there are three possible values for m_l
if $l = 2$ there are five possible values for m_l

if $l = 1 \rightarrow m_l = 0, \pm 1$
if $l = 2 \rightarrow m_l = 0, \pm 1, \pm 2$

n = 3
$l = 2$
= 3d orbital

n = 4
$l = 1$
= 4p orbital

Where Orbitals Are

If $l = 0$ then $m_l = 0$
*Shape of orbital shows how electron spends most of its time
*In an atom, majority of space is taken up by electrons

Summary of the First Three Numbers
*Boxes show where on energy axis electrons can go
*m_l values → places electrons can go
*If there are 3 values (0, $\pm$1) = 3 places electrons can go, there are 3 degenerate orbitals
*This QM model can be used to predict emission of elements other than hydrogen

Orbital Energies in Hydrogen (Only)
*Hydrogen has only one electron – spends most of its time in 1s orbital (ground state)
*Energy of different *l* values of hydrogen orbitals is degenerate

Orbital Energies in Multielectron Atoms
*Elements other than Hydrogen have *l* energy levels that are not degenerate (not straight line)
***Ground state of an element is when electrons are in the lowest possible energy state**
***Elements have only one ground state**

Magnetism of Materials
*4th quantum number is where the electron is
*Some materials will magnetize others will not
*Electricity and magnetism are coupled

Magnetism of Materials
*In every energy level – two electrons can fit, but have to be spinning the opposite way

How to Find the Ground State
**l* can only go up to n - 1
*If one electron is spin up (m_s = +½), the other electron must be spin down (m_s = -½).
*You need to know if a particular set of quantum numbers specifies an orbital which is possible or not

n = 3
l = 1 → 3p orbital
m_l = 0

n = 4
l = 1 → not possible because m_l cannot be 2 (can only go up to $\pm l$)
m_l = 2

n = 2
l = 2 → not possible because *l* cannot can only go up to n – 1
m_l = 0

*Quantum mechanics explains why the periodic table has its structure

Aufbau (Building) Elements
*No two electrons can have exact same numbers (one of the four must be different)
*An up arrow and a down arrow = 2 electrons in the same orbital with opposite spins
*Electrons spin up until all electrons are spinning up in one orbital, then they are paired with electrons that are spinning down
- Put up arrows in all boxes of an orbital
- Then go back and enter the down arrows

*Key is to give 2 different m_l values – any two of the possible – when writing the orbital states

Book's Representation
$1s^2 2s^1$ = 2 electrons in 1s orbital (having opposite spins), 1 electron in 2s orbital
*When writing shorthand notation, need to know if there are degenerate energy levels
*Hint to identifying elements by shorthand notation

Which corresponds to Neon?

1. Add superscripts together (total number of electrons)
2. Total # electrons = Atomic number
3. Atomic number identifies element

Aufbau (Building) Elements
*****Very important
- Valence electrons
- Core electrons

*Noble gas core
Core = Number of electrons in first noble gas underneath the element in question
Valence = Number of electrons outside of the core (extra electrons)

Scandium
spdf notation written with noble gas core

[Ar] $4s^2 3d^1$

Noble Gas Core **Valence**

Germanium
[Ar] $4s^2 3d^{10} 4p^2$

*Argon is the closest noble gas below Germanium
*Start counting electrons at the lowest orbital
*Argon has 18 Electrons (core)
*There are 14 electrons left over (valence)
*To know the noble gas core, you need the periodic table

The game of Quantum Mechanics: What you need to know
Know this slide