Week 7/Th: Lecture Units ‘17 & 18’

Unit 16: Electron standing waves
-- uncertainty, quantum numbers
-- properties of standing waves
-- shapes and nodes, labels
-- electron-electron repulsion

Unit 17: Electron orbitals
-- electron spin
-- electron configurations

Unit 18: Periodicity
-- periodicity of elements
-- radii, ionization, affinity
-- electronegativity

Unit 19: Chemical Bonding

Issues: ?

Homework #5 due this Saturday, Oct. 13th 8am
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With many electrons, the energy depends on “n” and also slightly on “l”.

It would be good if we found a factor of two …
Continued studies of the electron [and the proton and neutron] showed that they each have a magnetic moment – that is, each particle behaves as if it is a tiny magnet. Similar to a compass needle in the earth’s magnetic field, an electron can have two stable positions in a magnetic field: exactly aligned with the field or exactly anti-aligned, nothing in-between will be stable. This is feature is called “spin” because a rotating electric charge creates a magnetic field.

Here we find our missing factor of two. We can put two electrons into each orbital if we pair the magnetic moments. A fourth quantum number that, combined with the other three, is used to identify each electron in an atom.
Week 7/Th: Energy Levels for Shoes

Linda Bennett – Boise State Univ.

Edtech2.boisestate.edu/lindabennett1/502/Periodic Table e config/electron configuration.html

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Now we are ready to fill up the energy level diagram with electrons.

1) Fill from the bottom (duh). Lowest energy, “Aufbau”

2) Only two electrons with opposite spins per orbital. “Exclusion”

3) Electrons spread out, align spins among degenerate orbitals.
   “Maximum Multiplicity” .. “Maximum Spin”

QN Labels: \((n, l, m_l) m_s\)

Hydrogen, \(1e^-\) \((1,0,0) +1/2\) or \((1,0,0) -1/2\)
[only one electron so no difference for spin] or \(1s^1\)

Helium, \(2e^-\) \((1,0,0) +1/2\) for one
\((1,0,0) -1/2\) for the other. or \(1s^2\)
Now we are ready to fill up the energy level diagram with electrons.

1) Fill from the bottom (duh). Lowest energy, “Aufbau”
2) Only two electrons with opposite spins per orbital. “Exclusion”
3) Electrons spread out, align spins among degenerate orbitals.
   “Maximum Multiplicity” .. “Maximum Spin”

QN Labels: \((n, l, m_l, m_s)\)

Lithium, 3e
- \((1,0,0) +1/2\) for one
- \((1,0,0) -1/2\) for the next

Then a choice \((2,0,0) +1/2\) or \((1,0,0) -1/2\) or \(1s^22s^1\)

Beryllium, 4e
- \((1,0,0) +1/2\) for one
- \((1,0,0) -1/2\) for the next
- \((2,0,0) +1/2\) for the next
- \((2,0,0) -1/2\) for the last  or \(1s^22s^2\)
Now we are ready to fill up the energy level diagram with electrons.

1) Fill from the bottom (duh). Lowest energy, “Aufbau”
2) Only two electrons with opposite spins per orbital. “Exclusion”
3) Electrons spread out, align spins among degenerate orbitals.
   “Maximum Multiplicity” .. “Maximum Spin”

Boron, 5e⁻  
(1,0,0) +1/2  for one  
(1,0,0) -1/2  for the next  
(2,0,0) +1/2  for the next  
(2,0,0) -1/2  for the next  
SIX choices for next one !!!  
or 1s²2s²2p¹

(2,1,-1) +1/2  (2,1,0) +1/2  (2,1,1) +1/2  
(2,1,-1) -1/2  (2,1,0) -1/2  (2,1,1) -1/2
How about Manganese Z=25?

Manganese, 25e⁻ 1s²2s²2p⁶3s²3p⁶ 4s²3d⁵
[Ar] 4s²3d⁵
How about Ruthenium Z=44?

Ruthenium, 44e- \(1s^22s^22p^63s^23p^64s^23d^{10}4p^6\) 5s\(^2\)4d\(^6\) [Kr] 5s\(^2\)4d\(^6\)
The simple filling of the atomic energy levels provides a basis for understanding a wide range of chemical behavior.

- Atomic Radii and Iso-electronic Radii
- Ionization Potential
- Electron Affinity
- Electronegativity
Week 7/Th: Atomic Radii

Neutral atoms: covalent radii extracted from data from simple molecules. Unfortunately, two variables the number of electrons and number of protons.

Periodic Table of the Elements

College of Saint Benedict / Saint John's University

With covalent radii in Angstroms (10^{-10} m); based on data from Cambridge Crystallographic Database.¹


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Iso-electronic atoms and ions have the same number of electrons but the charge on the nucleus is different. Only one variable (atomic number). Larger charge on nucleus, same Principal QN .. Smaller radius.
The *ionization energy* is the minimum amount of energy to remove the least-bound electron from a neutral atom. E.g., $\text{He} \ (g) \rightarrow \text{He}^+ + e^- + \Delta E$

S & P block elements have a pattern of 2,3,3

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The ionization energy is the minimum amount of energy to remove the least-bound electron from a neutral atom. E.g., $\text{He} \ (g) \rightarrow \text{He}^+ + e^- + \Delta E$
The *electron affinity* is the energy change when an electron is added to a neutral atom. E.g., \( ^6\text{C} \ (\text{g}) + \text{e}^- \rightarrow ^6\text{C}^- \ (\text{g}) + \Delta E \) compared to \( ^7\text{N} \ (\text{g}) + \text{e}^- \rightarrow ^7\text{N}^- \ (\text{g}) + \Delta E' \)
The electronegativity is a function that combines the ionization potential and the electron affinity to describe the relative ability of an atom to “attract” electrons to itself that was introduced by Linus Pauling and elaborated by others. Remember both of these functions follow the same pattern in the Periodic Table.

We will use electronegativity next week to describe electron sharing in bonds.