Lecture 23
Chapter 8  Sections 3-4

• Electron Configurations
• Magnetism
• Atom properties
  • size
  • ionization energy
  • electron affinity
Announcements

• Seminar today – regulation

• CAPA #13 tonight, CAPA #14 Tuesday, Exam Friday
Valence Electrons

• The chemical properties of an atom are determined by the electrons that are easily accessible to other atoms.
• An electron is \textit{spatially} accessible when it occupies one of the largest orbitals of an atom.
• An electron is \textit{energetically} accessible when it occupies one of the least stable occupied orbitals of the atom.
• Accessible electrons are called \textit{valence electrons}.
  – Valence electrons participate in chemical reactions.
  – Core electrons do not.
• \textbf{Valence electrons are those of highest principle quantum number plus those in partially filled d and f orbitals.}
  – Electrons with lower $n$ values are core electrons.
How many valence electrons in Bromine?

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Electron Configuration

- Simply a way of listing where all of the electrons are

- Example Carbon
  - 6 total electrons, start filling them in using aufbau and the Pauli Exclusion Principle
  - Remember energies of orbitals…

So, we put 2 electrons in 1s, 2 in 2s, and have 2 left for 2p
The electron configuration for C is:
1s² 2s² 2p²
Hund’s Rule: The most stable configuration is the one with the maximum number of electrons with the same spin orientation.
How about Manganese?

25 total electrons: $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6 \ 4s^2 \ 3d^5$

By the way, what is total spin of Mn?

$\frac{1}{2} - \frac{1}{2} = 0$ for all pairs of electrons – all filled orbitals

$5(\frac{1}{2}) = 5/2$ in the 3d orbital.

Total spin for this electron configuration is $5/2$. 
How about a couple exceptions!

- Cr has one less electron than Mn
- 24 total electrons: \(1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6 \ 4s^1 \ 3d^5\)
- Cu has 29 electrons: \(1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6 \ 4s^1 \ 3d^{10}\)

In the first 40 elements these are the only 2 exceptions. See text p.314-315 for other exceptions.
Magnetism

- Remember Mn

![Electron configuration diagram]

Total spin for this electron configuration is $\frac{5}{2}$.
Because spin is $>0$, Mn is called **paramagnetic** and it is affected by magnets.

Zinc has 30 electrons

![Electron configuration diagram]

Total spin now is zero. Zinc is called **diamagnetic** and is unaffected by magnets.
What is the electron configuration of H?

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What is the electron configuration of a hydrogen atom with an energy of $-5.45 \times 10^{-19}$ J?

Recall that for hydrogen: 

$$E = \frac{-2.18 \times 10^{-18}}{n^2}$$

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Electron configuration tells us whether an atom is in the ground state or not

• There is only one configuration that is most stable
  – This is the ground state
• Many other configurations are possible and perfectly allowable
  – They simply have higher energy – excited states

Na ground state: 1s$^2$ 2s$^2$ 2p$^6$ 3s$^1$
excited states: 1s$^2$ 2s$^2$ 2p$^6$ 3p$^1$
  1s$^2$ 2s$^2$ 2p$^5$ 3s$^2$
Another example, Cl

- 17 total electrons
- $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^5$

What about Cl$^-~$?

- 18 total electrons
- $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6$
Noble Gas Shorthand

- Recall chlorine: $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^5$
- Note that neon is: $1s^2 \ 2s^2 \ 2p^6$

- So, we often write chlorine more conveniently:
  $[\text{Ne}] \ 3s^2 \ 3p^5$

- What about the anion $\text{Cl}^-$?
  $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6$
  $1s^2 \ 2s^2 \ 2p^6 \ 3s^2 \ 3p^6$
  $[\text{Ar}]$

$\text{Cl}^-$ and Ar are isoelectronic – same number of electrons
Periodic Properties

• Atomic Radii
  – Distance between center of nucleus and outer electron shell

• Ionization Energy
  – Energy required to remove an electron from an atom in the gas phase – energy to make a cation
  – Na → Na⁺ + e⁻

• Electron Affinity
  – The energy change when an electron is added to an atom – energy to make an anion
  – F + e⁻ → F⁻
Atomic Radii

• For the main group elements, the atomic radius of atoms increases going to the left and down on the periodic table.
  – Fr is the largest element, He is the smallest
  – Going down a group, $n$ increases
  • adding extra shells, thus the atoms are larger

  – Going across a period, $n$ is constant, adding electrons, protons and neutrons, result is an increase in $Z_{\text{eff}}$
  • Nucleus has stronger pull on the outer electrons, thus the atoms are smaller
Ionization Energy

- For the main group elements, the IE increases going up and across to the right of the periodic table.
  - Na has small IE, F has large IE
  - Going down a group, $n$ increases
    - Adding extra shells, thus the atoms are larger, easier to remove an electron, thus IE decreases

- Going across a period, $n$ is constant, adding electrons, protons and neutrons, result is an increase in $Z_{\text{eff}}$
  - Nucleus has stronger pull on the outer electrons, harder to remove
Electron Affinity

• For the main group elements, the EA tends to become more negative from left to right across a row of the periodic table.
  – F like to take on an extra electron more than Na.
• No obvious trend is observed moving down the periodic table.
Today

• Seminar
• CAPA #13 due tonight
• Take old exam if you haven’t already!!!!!!!!!

By Monday

• Finish Chapt 8
• Work extra problems!
• Start CAPA #14

Remember: You are done with the homework when you understand it!