

AP Chemistry

Chapter 7 Outline

7.1 Skip this section

- a) Effective Nuclear Charge
- Negatively charged electrons are attracted to the positively charged nucleus.
 - Coulomb's Law...key concept emphasized on AP exam
 - Force of attraction *increases* as the nuclear charge increases
 - Force of attraction *decreases* as the electron moves farther from the nucleus
 - We can estimate the net attraction of each electron to the nucleus
 - Z_{eff} : effective nuclear charge VERY IMPORTANT CONCEPT!
 - $Z_{\text{eff}} < Z$
 - Shielding effect: Inner electrons partially "shield" the outer electrons from the positive charge of the nucleus
 - $Z_{\text{eff}} = Z - S$ where S is "screening constant"
 - S is close to the number of core electrons in an atom
 - Z_{eff} increases as we move from L to R in a period
 - The actual number of protons increases L to R (increased coulombic attraction), but the number of core electrons is unchanged (energy level being filled isn't changed)
 - Outermost electrons are more strongly attracted to nucleus
 - Going down a column, Z_{eff} increases slowly (compared to the L to R change)
 - This is because larger electron cores are less effective at screening
 - More electron-electron repulsions
 - Electrons are placed in energy levels intrinsically farther from nucleus
 - Period L \rightarrow R change in Z_{eff} is far more significant than group top to bottom change.
- b) Sizes of Atoms and Ions
- Atomic size can't be measured directly, but can be indirectly determined
 - Nonbonding atomic radius: based on the closest distances separating the nuclei during collisions of non-bonded atoms
 - Also known as "van der Waals radii"
 - Bonding atomic radius: based on the distances separating nuclei of chemically bonded atoms
 - Also known as "covalent radii"
 - Atomic radii can be used to estimate bond lengths between different elements in molecules—based on the sum of the atomic radii
 - Periodic Trends in Atomic Radii
 - Group trend: atomic radius tends to increase from top to bottom
 - Why? Because there is an increase in the principal quantum number (n) of the outer electrons. Down a column: outer electrons have greater possibility of being farther from the nucleus.
 - Z_{eff} increases slowly down a group—large electron cores aren't that effective at shielding

- (i) Net effect: outermost electrons are held less tightly
 - (2) Period Trend: Atomic radius tends to decrease from left to right.
 - (a) Why? Z_{eff} increases as you go L to R; the valence electrons are held more tightly, causing the atomic radius to decrease.
 - iv) [Periodic Trends in Ionic Radii](#) [Another good interactive](#)
 - (1) Cations are smaller than their parent atoms.
 - (a) Why? Farthest-out occupied orbitals are emptied, and there are fewer electron-electron repulsions.
 - (2) Anions are larger than their parent atoms.
 - (a) Why? More electrons, so more electron-electron repulsions, so electrons spread out more in space.
 - v) For ions carrying the same charge, size increases as we go down a column.
 - (1) Isoelectronic series = group of ions all containing the same number of electrons
 - (2) As nuclear charge increases, (i.e., in order of increasing atomic number), radius decreases because electrons are more strongly attracted to the nucleus. You need to be able to predict and explain these trends and patterns!
- b) Ionization Energy
- i) IE = the minimum amount of energy required to remove an electron from the ground state of the isolated atom or ion
 - (1) The measure of the ease with which an atom loses an electron
 - ii) The greater the ionization energy, the more difficult it is to remove an electron.
 - (1) First IE = energy to remove 1st electron from a neutral atom
 - (a) $A + \text{IE}_1 \rightarrow A^+ + e^-$
 - (2) Second IE = energy to remove the second electron
 - (a) $A^+ + \text{IE}_2 \rightarrow A^{2+} + e^-$
 - iii) Variations in Successive Ionization Energies
 - (1) $\text{IE}_1 < \text{IE}_2 < \text{IE}_3$ for a given element
 - (a) With each successive removal, an electron is being pulled away from an increasingly more positive ion, requiring increasingly more energy.
 - (2) Sharp increase in IE when an inner-shell electron is disturbed!
 - (a) Core electrons experience a greater nuclear charge. (These orbitals are more “penetrating.”)
 - (3) Large increase in IE when electrons are removed from noble-gas core.
 - (a) Tightly bound to nucleus! Disrupting a spherically symmetric electron cloud, which minimizes electron-electron repulsions
 - iv) [Periodic Trends in First Ionization Energies](#)
 - (1) Period Trend: IE_1 generally increases with increasing atomic number
 - (a) Increasing Z_{eff} & decreasing average distance from nucleus \rightarrow more attraction of electrons to nucleus, so harder to remove
 - (2) Group Trend: IE_1 generally decreases with increasing atomic number
 - (a) Increasing Z_{eff} , increased shielding, increasing radius \rightarrow less attraction of electrons to nucleus, so easier to remove
 - (3) Irregularities: filling higher energy subshells, or increasing repulsion of electrons among partially filled degenerate orbitals

- v) Electron Configurations of Ions
 - (1) Cation formation: take electrons from occupied orbitals having largest principal quantum number (n)
 - (2) Anion formation: add electrons to empty/partially filled orbital having the lowest value of n

- a) [Electron Affinities](#)
 - i) EA = the energy change that occurs when an electron is added to an isolated, gaseous atom; measure of the attraction of an isolated atom for an electron
 - (1) The measure of the ease with which an atom gains an electron
 - (2) The greater the attraction between a given atom and an added electron, the more negative the EA for that atom
 - ii) Halogens have the most negative electron affinities because it would involve achieving a noble-gas like electron configuration
 - iii) Metals tend to have slightly negative or even positive electron affinities
 - iv) Noble gases have positive electron affinities because it would involve adding electrons to a higher energy empty orbital
 - v) Electron affinities do not change greatly down a group

I'm not going to outline Sections 7.6-7.8; however, you should read these sections (which are largely review) and be familiar with the material!