Coulombic Interactions

Intro: The Coulombic interactions that we will focus on are the interactions between (B/w) electrons and nuclei and how these interactions give way to the unique electronic structure of each element

Coulombs Law - States that the force B/w 2 charged particles is proportional to the magnitude of the charge and inversely proportional to the square of the distance B/w them

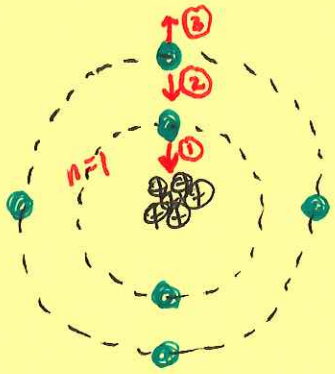
$$F \propto \frac{Q_1 Q_2}{r^2}$$

* Like charges Repel
* opposite charges attract

Look at distance first then Look at charges!

* squared distance will have larger effect on Attraction or Repulsion than charges themselves

C
6p+
6e-



Forces Present in C atom

1.) force B/w n=1 electron and nucleus
electron negative, proton positive so force = attractive

2.) force B/w n=2 electron and nucleus
Attractive force not as large as force #1 because n=2 further from nucleus
↳ Larger r = less attractive force and less tightly held

3.) force B/w n=2 electron and n=1 electron
Repulsive force since both electrons negative
↳ not stronger than force #2 (or e- would be ejected) but does reduce overall Attraction to nucleus

* Compare force #1 versus force #2 and understand why one is larger than the other

Ionization Energy - energy required to remove an electron (e^-) from an element in the gaseous state

→ provides evidence for the distribution of e^- in the atoms

↓

All links back to Coulombic interactions

Carbon

IE_1 = 1090 KJ/mol $\quad X_{(g)} \rightarrow X^+ + e^-$

IE_2 = 2350 KJ/mol $\quad X^+_{(g)} \rightarrow X^{2+} + e^-$

IE_3 = 4620 KJ/mol

IE_4 = 6220 KJ/mol

IE_5 = 37,800 KJ/mol

First ionization energy is the minimum energy needed to remove the least tightly held electron → generally e^- farthest from nucleus according to Coulombic interactions

* Carbon has 6 e^- so it should have 6 IE
  - ↳ each e^- will have it's own IE

Trends from IE data

* IE increasing with each subsequent e^- removal
  - ↳ But $IE_2 \rightarrow IE_4$ jumps not all that large B/c all e^- in same energy shell
    - ↳ same energy shell = same distance from nucleus!

* Know why e^- that is closer to nucleus requires more energy to remove!!

* IE_5 is a VERY LARGE energy jump
  - ↳ denotes 5th e^- removed is from inner energy shell
    - ↳ allows us to distinguish e^- in 1 shell versus e^- in another B/c of differences in energy

* Comparing 2 species with the same electronic structure, the element with the higher nuclear charge (more p+) = higher IE for each given shell/subshell

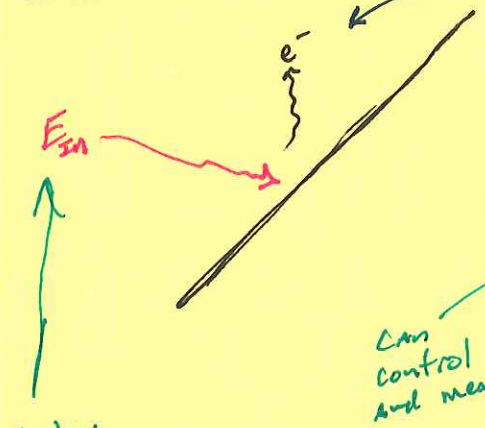
C -vs- N ←

* since same electronic structure each comparable e^- has same r^2 value
  - ↳ But charge increased b/c of more p+

Photoelectron Spectroscopy - based on photoelectric effect and that ionization occurs when ~~light~~ elements interacts with light of sufficient energy

gives us evidence for distribution of electrons in atoms

electrons ejected b/c of light energy



Law of conservation $E_{In} = E_{out}$

E_{In} = Light Energy Input = BE (Binding Energy) + KE (Kinetic Energy)

KE: Can measure

Can control and measure

Energy needed to overcome Coulombic forces of attraction within atom to eject e⁻ from atom

$E = h\nu$

E = energy

* can calculate this

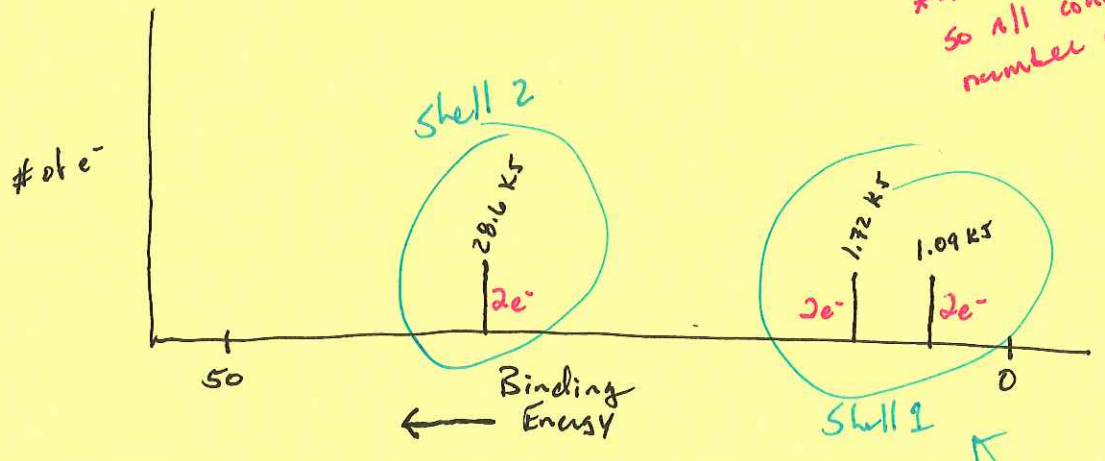
Photoelecton Spectra

↘ peak height = # of e⁻

* all 3 peaks equal so all contain same number of e⁻

C

6 e⁻



separation of energies

2 diff peaks in shell 1 is evidence for subshells (s, p)