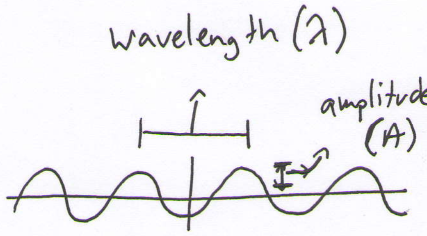
Final Exam Review – Day 2

Light has properties of particles and waves →



↓
photons
↓

$$E_{photon} = E_{light} = hf = \frac{hc}{\lambda}$$

h = Planck's constant = 6.626×10^{-34} J·s

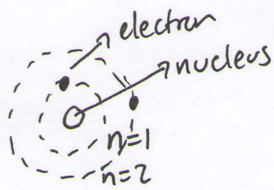
c = speed of light = 3×10^{8} m/s

f = frequency (1/s)

Electrons have properties of particles and waves

old → Bohr Model; new → Wave Model

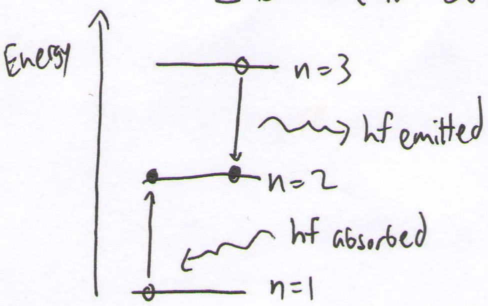
Bohr Model



* e^- in discrete (quantized) orbits
* light emitted / absorbed when e^- jump between orbits

$$E_{light}^{abs/emit} = \Delta E = \frac{hc}{\lambda_{light}}$$

$$\Delta E = E(n_1) - E(n_2)$$

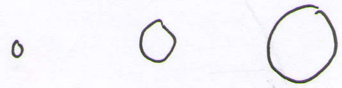


Ground State = lowest-energy state of an atom

Excite State = any other state

l(s) = 0   l(d) = 2
l(p) = 1   l(f) = 3

n: =1   =2   =3

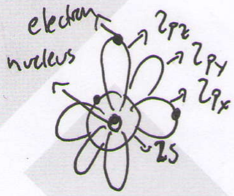


l: =0 (s)   =1 (p)   =2 (d)

m_l (l=1): =−1   =0   =+1

m_s: = +1/2 ↑   = −1/2 ↓

Wave Model



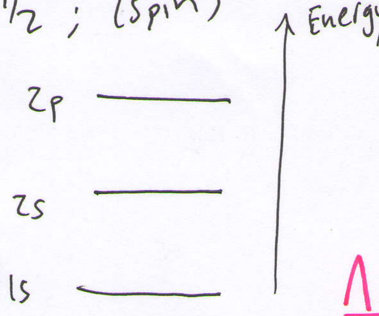
* e^- in orbitals
* can only give probability of finding an electron
* location of e^- given by quantum #'s

n = 1, 2, …; (size)

l = 0, 1, …, (n−1); (shape)

m_l = 0, ±1, …, ±l; (orientation)

m_s = ± 1/2; (spin)



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Aufbau Principle (for ground-state electron configurations):

1) Golden Rule: e^- occupy orbitals in an atom such that the atom has the lowest-possible energy ($H: 1s^1$ vs $H: 3s^1$) and ($C: 1s^2 2s^2 2p^2$ vs $C: 1s^2 2s^2 2p^1 3s^1$)

2) Hund's Rule: e^- occupy orbitals with the same energy one-at-a-time with all spins in the same direction until all orbitals with the same energy are occupied by one electron

(↑ ↑ ↑ (good) vs ↑↓ ↑ __ (bad) vs ↑ ↓ ↑ (bad))

3) Pauli Exclusion Principle: no two e^- can share the same four quantum numbers; e^- in the same orbital must have opposite spins

(n, ℓ, m_ℓ)

$4s^2 \Rightarrow n\ell^{\#}$

Exceptions: Cr, Cu, Ag, Au

$Cr: [Ar]\,4s^1 3d^5$ ([Ar] ↑↓ (4s) ↑ ↑ ↑ ↑ __ (3d) → [Ar] ↑ (4s) ↑ ↑ ↑ ↑ ↑ (3d))

$Cu: [Ar]\,4s^1 3d^{10}$
$Ag: [Kr]\,5s^1 4d^{10}$
$Au: [Xe]\,6s^1 4f^{14} 5d^{10}$

([Noble Gas] ↑↓ (ns) ↑↓ ↑↓ ↑↓ ↑↓ ↑ ((n−1)d) → [Noble Gas] ↑ (ns) ↑↓ ↑↓ ↑↓ ↑↓ ↑↓ ((n−1)d))

To make cations, remove e^- from orbitals with the highest n first. If two e^- have the same n, remove e^- with highest ℓ first.

$Ti: [Ar]\,4s^2 3d^2 \rightarrow Ti^+: [Ar]\,4s^1 3d^2$

$C: [He]\,2s^2 2p^2 \rightarrow C^+: [He]\,2s^2 2p^1$

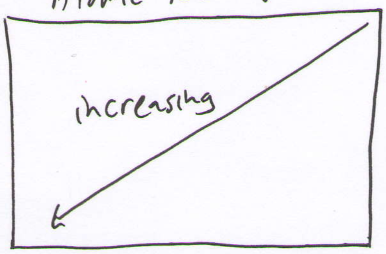
To make anions, add e^- to next-highest-energy orbital, just as you would for neutral atoms

$O: [He]\,2s^2 2p^4 \rightarrow O^{2-}: [He]\,2s^2 2p^6 = [Ar]$

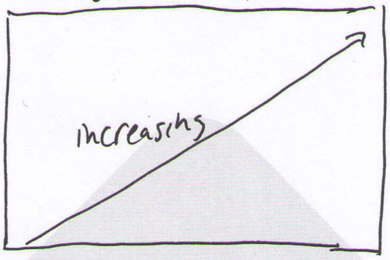
Periodic Properties: elements w/ similar e^- configurations have similar physical and chemical properties

$Z_{eff} = Z - (\# \text{ core } e^-) \equiv$ effective nuclear charge experienced by valence e^-

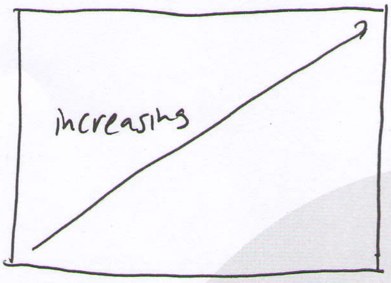
Atomic Radius (AR)



Ionization Energy (IE)

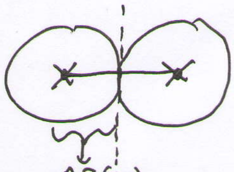


Electronegativity (EN)



Period: $Z_{eff}\uparrow$, AR$\downarrow$

Group: $n\uparrow$, AR$\downarrow$



Period: $Z_{eff}\uparrow$, IE$\uparrow$

Group: $n\uparrow$, IE$\downarrow$

IE: energy needed to remove e^- from an atom

$r(C^+) < r(C) < r(C^-)$

Period: $Z_{eff}\uparrow$, EN$\uparrow$

Group: $n\uparrow$, EN$\downarrow$

EN: tendency of an element to "steal" e^- in ~~[illegible]~~ chemical bond

* Cations (anions) have smaller (larger) radii than neutral atoms of the same element
* Atoms and ions w/ the same # of e^- are called isoelectronic   C and N^+
* The more negatively charged (positively charged) of two isoelectronic species has the larger (smaller) radius $r(Na^+) < r(Ne) < r(F^-)$

* Noble-gas electron configurations are especially stable

Many elements tend to gain/lose e^- to become ions w/ noble-gas e^- configurations

Li: [He]$2s^1$ → Li^+: [He]   B: [He]$2s^2 2p^1$ → B^{3+}: [He]   O: [He]$2s^2 2p^4$ → O^{2-}: [Ne]

Be: [He]$2s^2$ → Be^{2+}: [He]   N: [He]$2s^2 2p^3$ → N^{3-}: [Ne]   F: [He]$2s^2 2p^5$ → F^-: [Ne]