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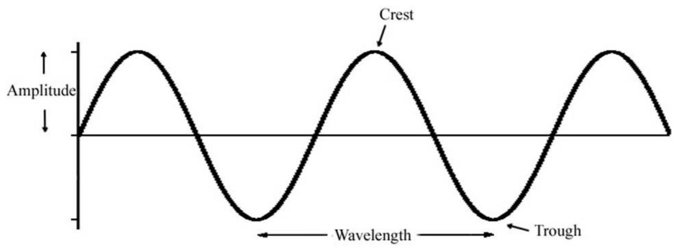
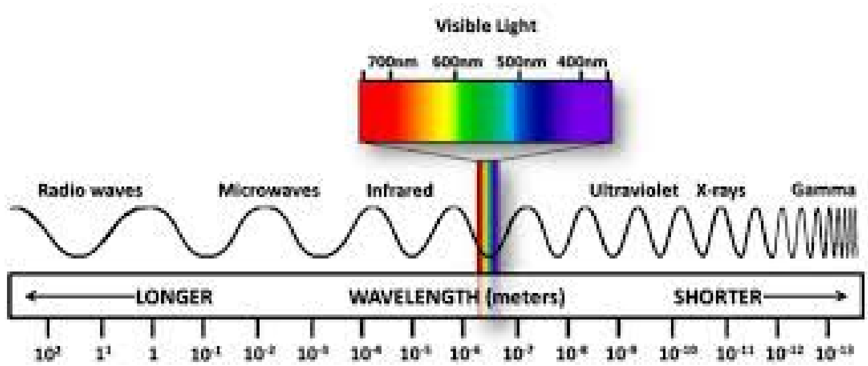
Chapter 5: Electrons in Atoms Study Guide

Electromagnetic Waves

- all electromagnetic waves have three characteristic properties



  - frequency (v, f)
    - number of waves the pass in a certain time frame
    - measured in hertz (Hz), one wave per second
  - wavelength (λ)
    - length of wave (distance between two corresponding parts of adjacent waves)
    - measured in metric distances (m, nm, km, etc.)
  - speed (c)
    - all electromagnetic waves travel at the speed of light, c, 3.00x10^8m/s
  - relationship: $c = \lambda v$
- "spectrum" is a band of colors or wavelengths (and frequencies)
  - visible light spectrum includes the colors we see
    - white light includes all of the visible light colors
    - a form of continuous spectrum (like the electromagnetic spectrum) because each part corresponds to a certain wavelength of light
  - electromagnetic spectrum has all of the wavelengths, all of the forms of electromagnetic radiation



Quantum Theory

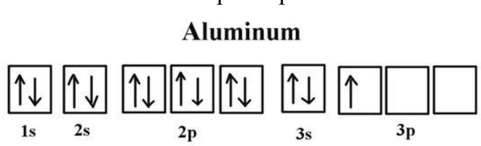
- matter can only gain or lose energy in small amounts (whole number multiples of quanta)
- a quantum is the minimum amount of energy that can be gained or lost by an energy; $E = hv$
  - h = Planck's constant, $6.626 \times 10^{-34} Js$
- Einstein proposed the idea of particle-like energy bundles (photons) with a quantum of energy
  - this was because of his observation of the photoelectric effect and how there was a minimum required energy of the energy input to have the emission of a photoelectron — it couldn't be a continuous wave
- major theorists:
  - Bohr model doesn't explain the exact arrangement of models, why they didn't get pulled into the nucleus, chemical properties, and more (see emission spectra series below) — needed the quantum mechanical model

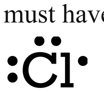
- Louis de Broglie proposed that electrons act as a particle and a wave, and it is allowed certain frequencies and energies
  - $\lambda = \frac{h}{mv}$ (where *m* = mass; therefore, the larger the mass, the shorter the wavelength)
- Heisenberg said that it is fundamentally impossible to know both the velocity and position of a particle at the same time; you have to stop one to know the other (the "uncertainty principle")
  - also, photons make a big difference to electrons — observing would affect it (the "observer effect")
- Schrodinger derived the wave equation that treated the electron of the hydrogen atom as a wave, and it worked well with other elements as well
  - wave function also put limits to electrons' orbits (defined the space of an orbital, a 3D space that describes an electron's probable location) — this showed probability, no defined orbits like in Bohr's model
  - also came up with the Schrodinger's cat paradox: a cat can be superpositioned as both alive and dead until the observer opens it, light interferes, and the wave function (probability) collapses

Atomic Emission Spectra

- ground state is the lowest allowable energy of an electron
- electrons can be excited (usually by absorbing thermal or electrical energy) so that the atom goes into an excited, unstable state; as it releases energy to achieve stability (at its ground state) it releases energy in the form of electromagnetic radiation
- because only certain energy levels exist, only certain frequencies (and colors and wavelengths) can be emitted
  - Balmer series is the visible light emission spectrum of H
  - Lyman series is UV emission
  - Paschen series is infrared emission

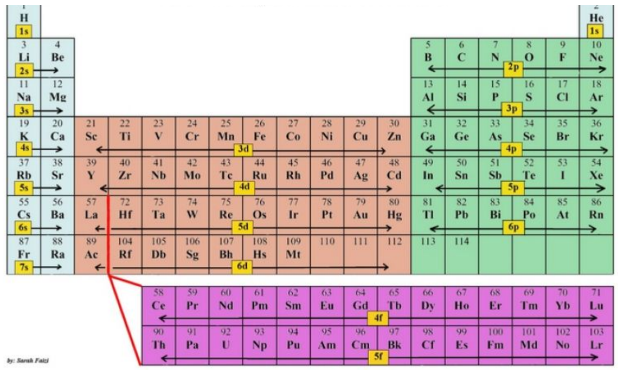
Electron Configuration Representations

- electron configuration
  - a series of sublevels in the form ab^c where a = energy level, b = sublevel (letter), c = number of electrons in sublevel
  - ordered with energy levels in increasing order (shows valence electrons, but not order of filling)
  - doesn't show well any of the three principles, but is most convenient
  - example: Uuo = $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 5f^{14} 6s^2 6p^6 6d^{10} 7s^2 7p^6$
  - can be shortened using the last noble gas, example: Uuo = [Rn] $5f^{14} 6d^{10} 7s^2 7p^6$
- quantum numbers
  - represents only the outermost electron, and therefore unique for every element
  - in the form n, l, m_l, m_s where n = principal quantum number (energy level), l = sublevel (0 = s, 1 = p, 2 = d, 3 = f), m_l = orbital of sublevel (starts from 0, goes both ways), m_s = spin
  - shows well the Pauli-exclusion principle
  - example: H = 1, 0, 0, +½
- orbital diagram
  - shows well all three principles
  - 

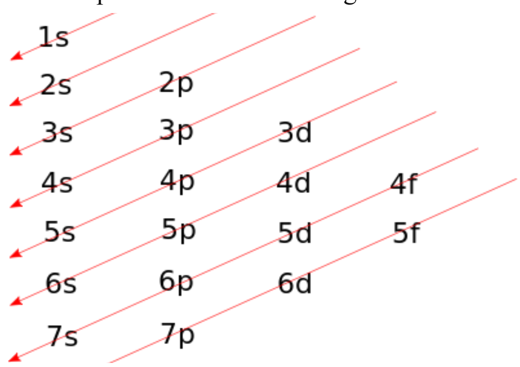
  - can be simplified using the previous noble gas (see "electron configuration")
- Lewis dot diagram
  - shows valence electrons
  - must have first two grouped together (s), and then the rest go evenly spaced, and then in pairs
  - 

- governing rules:
  - Aufbau principle (diagonal rule)
    - sublevels fill by order of increasing energy

        - $1s^2 \rightarrow 2s^2 \rightarrow 2p^6 \rightarrow 3s^2 \rightarrow 3p^6 \rightarrow 4s^2 \rightarrow 3d^{10} \rightarrow 4p^6 \rightarrow 5s^2 \rightarrow 4d^{10} \rightarrow 5p^6 \rightarrow 6s^2 \rightarrow 4f^{14} \rightarrow 5d^{10} \rightarrow 6p^6 \rightarrow 7s^2 \rightarrow 5f^{14} \rightarrow 6d^{10} \rightarrow 7p^6$
            - there are some exceptions to this rule, mostly almost-filled and almost-half-filled *d* sublevels, which steal from the next *s* sublevel for stability (Cr, Cu, Mo, Ag, Pt, Au)
            - is well represented in the periodic table



        - can be represented with the "diagonal rule"



    - Pauli exclusion principle
        - orbitals fill with opposing charges (+½ or -½)
    - Hund's rule
        - orbitals of a sublevel all have the same energy, so all orbitals of the same sublevel are first singly filled (all with +½ spin) before any are doubly filled

Other Info to Know?

- the fireworks article she said she was going to test us on?
    - light with incandescence and luminescence
- history of the atom
    - Democritus (and Aristotle) → alchemists → Dalton (billiard ball) → Crookes → Thomson (plum pudding) → Becquerel → Millikan → Rutherford (planetary, nuclear) → Bohr → Schrodinger (electron cloud, wave, quantum mechanical) → Heisenberg
- basic skills
    - sigfig measurements, operations, rounding
- any recent pop culture for XC?