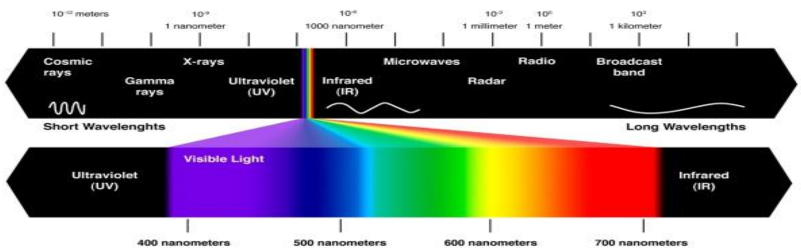
Electronic Structure of Atoms

Vocabulary

- Wavelength—the distance from one trough or peak to the next
- Frequency—the number of complete cycles in 1s
- Photon—energy particle which behaves like light
- Heisenburg Uncertainty Principle—it is impossible to know both the speed and location of an electron at the same time
- Effective Nuclear Charge—Z_{eff}; the number of protons – average number of electrons
- Shelding/ Screening—inner shell electrons shield valence electrons from protons' effects
- Pauli Exclusion Principle—each electron from an atom has a unique set of quantum numbers
- Degenerate Orbitals—orbitals with the same energy
- Hund's Rule—lowest energy is attained when the number of electrons with the same spin quantum number is maximum

Waves



Equations

- $c = \lambda v$
- $E = hv$
- $\lambda = \frac{h}{mv}$ (v here is velocity)

Constants

$h = 6.626 \times 10^{-34}$ J·s (Planck's constant)
$c = 3.00 \times 10^{8}$ m/s (Speed of light)

Sample Problems

1. What is the wavelength of a wave with a frequency of 4.0 mHz?
   $4.0 \text{ kHz} \times \frac{1000 \text{ Hz}}{1 \text{ kHz}} = 4.0 \times 10^{3}$ Hz
   $\frac{3.00 \times 10^{8} \text{ m/s}}{4.0 \times 10^{3} \text{ Hz}} = \lambda = 7.5 \times 10^{4}$ m
2. How much energy does the wave have?
   $E = (6.626 \times 10^{-34} \text{ J·s})(4.0 \times 10^{3} \text{ Hz})$
   $E = 2.7 \times 10^{-30}$ J
3. What is the velocity of an electron in that wave? (mass = 9.11×10^{-31} kg)
   $v = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34} \text{ J·s}}{(9.11 \times 10^{-31} \text{ kg})(7.5 \times 10^{4} \text{ m})} = 9.7 \times 10^{-9}$ m/s

Scientists

Bohr-used Rutherford's nuclear model and Pascal's quanta to postulate that electrons have fixed orbitals attached to specific quanta of energy.

De Broglie-came up with the idea that an electron can have a wavelength (and thus have wave properties).

Heisenberg-concluded that the wave nature of electrons made it impossible to know both position and velocity at once

Schrödinger-created wave functions to generate electron probability density (a vague idea of where an electron will be at any given instant)

Quantum Numbers

Equations/ Definitions

- $v = 3.29\times10^{15}$ Hz $(\frac{1}{2^2} - \frac{1}{n^2})$, where n = 3,4, 5, 6
- $E_n = (-R_H)\frac{1}{n^2} = (-2.18\times10^{-18} \text{ J})\frac{1}{n^2}$, where E_n is the energy of a particular orbital, and n is any principle quantum number (1 to ∞)
- $v = (\frac{R_H}{h})(\frac{l}{n_i^2} - \frac{l}{n_f^2}) = (2.18\times10^{-18} \text{ J})(\frac{l}{n_i^2} - \frac{l}{n_f^2})$, where n is any principle quantum number from 1 to infinity, and *l* is the azimuthal quantum number (n-1, for all n 1 to ∞)

Electronic Structure of Atoms

- n = principal quantum number (integers 1+)
- l = azimuthal quantum number (n-1)
- m_l = magnetic quantum number (integers $-l$ to $+l$, inclusive)
- m_s = electron spin quantum number (-1/2 or +1/2)

Quantum Numbers Key Data

n	l	m_l	Subshell	Orbitals in Subshell	Total Orbitals in Shell
1	0	0	1s	1	1
2	0 1	0 -1, 0, 1	2s 2p	1 3	4
3	0 1 2	0 -1, 0, 1 -2, -1, 0, 1, 2	3s 3p 3d	1 3 5	9
4	0 1 2 3	0 -1, 0, 1 -2, -1, 0, 1, 2 -3, -2, -1, 0, 1, 2, 3	42 4p 4d 4f	1 3 5 7	16

Electron Configuration

Rules:

- Obey Hund's Rule!!

Examples:

- Full EC
  - Li^+—$1s^2$
  - Cu—$1s^2 2s^2 2p^3 3s^2 3p^3 4s3d^{10}$ (This is an EXCEPTION because $4s3d^{10}$ EC is more stable than $4s^2 3d^{10}$)
- Noble-Gas Abbreviation
  - W—[Xe] $6s^2 4f^{14} 5d^4$
  - Cr—[Ar] $4s3d^5$ (This is an EXCEPTION because $4s3d^5$ EC is more stable than $4s^2 3d^4$)

Orbital Diagrams:

- N—

1s	2s	2p		
↑ ↓	↑ ↓	↑	↑	↑