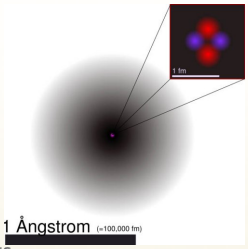
Atoms

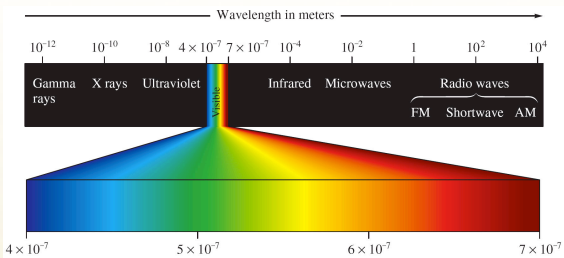
Our modern atomic model:

- Small compact nucleus containing protons & neutrons
- Mostly empty space
- volume ~ radii of electronic orbits



Electromagnetic Energy

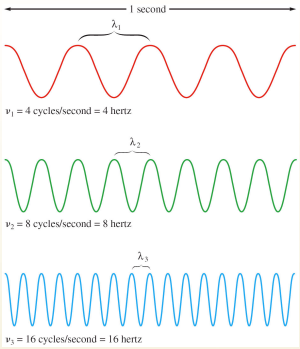
Studying atoms and their interaction with energy (light)



Light Waves

- Velocity = v = c
- Wavelength = λ
- Frequency = ν

$c = 2.9979 \times 10^{8}$ m/s = $\nu \times \lambda$



- The yellow light given off by the sodium vapor lamps has a wavelength of 589 nm – What is the frequency?

- The yellow light given off by the sodium vapor lamps has a wavelength of 589 nm – What is the frequency?

$c = 2.9979 \times 10^{8} = \nu \times \lambda$

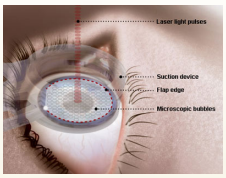
$\nu = c/\lambda$

$= 2.9979 \times 10^{8} / 589 \times 10^{-9}$ m

$= 5.09 \times 10^{14}\ s^{-1}$

Light Waves

Lasers used in eye surgery produce radiation with a frequency of $4.688 \times 10^{14}\ s^{-1}$ – what is the wavelength?



Light Waves

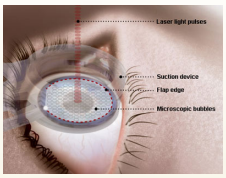
Lasers used in eye surgery produce radiation with a frequency of $4.688 \times 10^{14}\ s^{-1}$ – what is the wavelength?

$c = \nu \times \lambda$

$\lambda = c/\nu$

$= 2.9979 \times 10^{8}$ m/s/$4.688 \times 10^{14}\ s^{-2}$

$= 6.39 \times 10^{-7}$ m = 639 nm



Photons

Light acts like a wave AND a particle

Max Planck:

Light is emitted in discrete quantities (quanta) of energy

$E = h \times \nu$

$h = 6.626 \times 10^{-34}$ J•S = Planck's constant

Photons

- What is the energy emitted by sodium vapor lamps if $\nu = 5.09 \times 10^{14}\ s^{-1}$?

Photons

- What is the energy emitted by sodium vapor lamps if $\nu = 5.09 \times 10^{14}\ s^{-1}$?

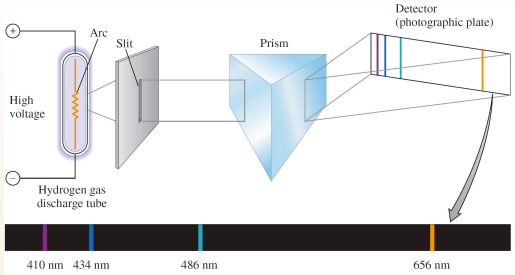
$E = h \times \nu$

$= (6.626 \times 10^{-34}\ J \bullet s)(5.09 \times 10^{14}\ s^{-}$

$= 3.37 \times 10\text{-}19\ J$

Hydrogen Spectrum

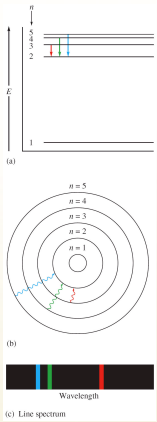
- Hydrogen gas subjected to high voltage



Bohr Model

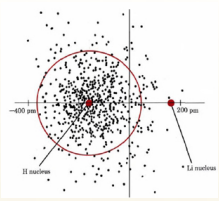
- Electrons can inhabit only certain allowed orbits and radiation is released or required to change orbits

$\Delta E = -2.178 \times 10^{-18}\ J\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$



Quantum Mechanics

- Probability map for electron location:

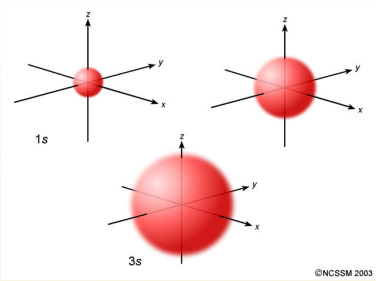


- **Heisenberg Uncertainty** principle

  Impossible to know the momentum and location of an electron simultaneously

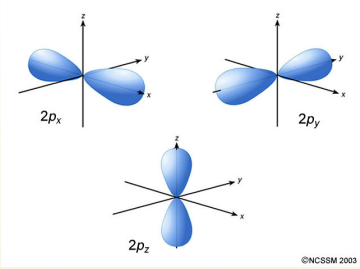
Orbitals

- S orbitals



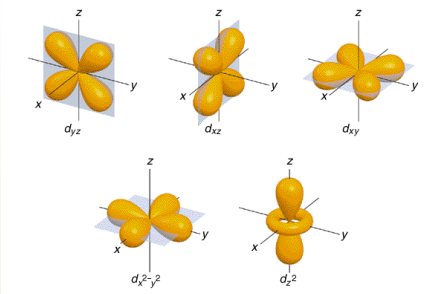
Orbitals

- P Orbitals



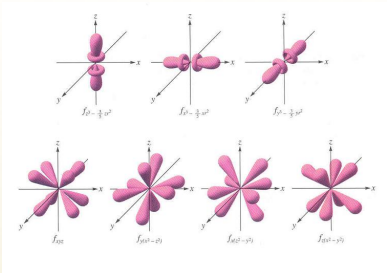
Orbitals

- D orbitals



Orbitals

- F orbitals

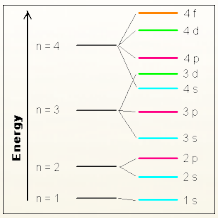


Electron Configurations

- ***# electrons = Z (atomic number)***

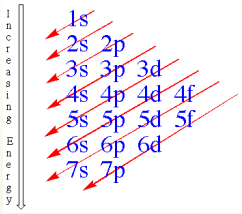
  for neutral atoms

- ***Aufbau Principle***
  - Fill lowest energy levels first



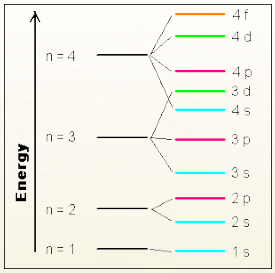
Electron Configurations

- Filling order



Electron Configurations

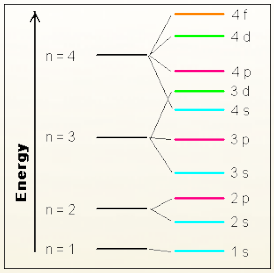
- What is the electron configuration for phosphorus?



Electron Configurations

- What is the electron configuration for phosphorus?

Phosphorus Z = 15

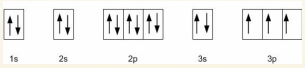


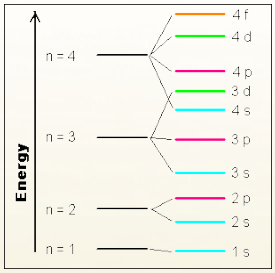
Electron Configurations

- What is the electron configuration for phosphorus?

Phosphorus Z = 15

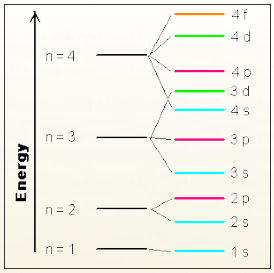
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$





Electron Configurations

- What is the electron configuration for titanium?

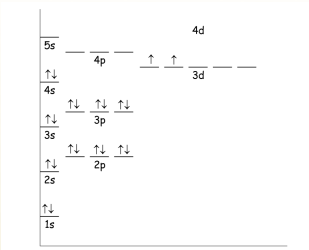


Electron Configurations

- What is the electron configuration for titanium?

Z = 22

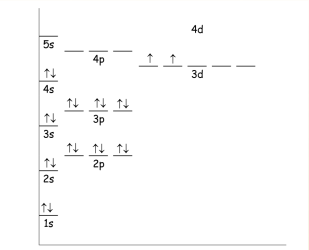
$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6 4s^2\ 3d^2$



Electron Configurations

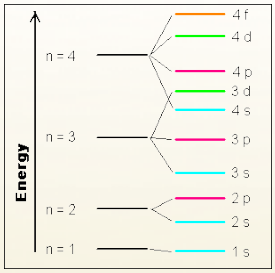
- What is the electron configuration for titanium?

Z = 22



Electron Configurations

- What are the electron configurations for sodium (Z = 11) and potassium (Z = 19) ?

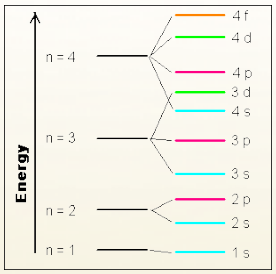


Electron Configurations

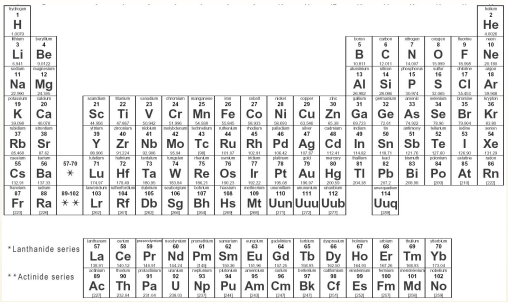
- What are the electron configurations for sodium (Z = 11) and potassium (Z = 19) ?

Na: $1s^2\ 2s^2\ 2p^6\ 3s^1$

K: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$



Periodic Table



Electron Configurations

All of the noble gases possess <u>filled</u> electron orbitals

He: $1s^2$

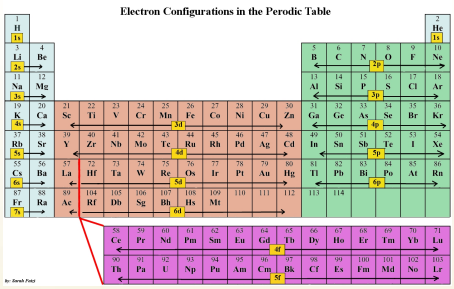
Ne: $1s^2\ 2s^2\ 2p^6$

Ar: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Kr: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$

Xe: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6\ 4d^{10}\ 5p^6$

Periodic Table



Valence Electrons

Valence Electrons = <u>Electrons in the Outermost shell</u>

K: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$ 1 valence electron Group 1A

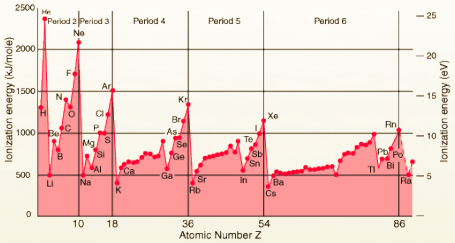
Al: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ 3 valence electrons Group 3A/13

Br: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p6\ 4s^2\ 3d^{10}\ 4p^5$ 7 valence electrons Group 7A/17

Periodic Properties

- Ionization Energy: energy needed to remove electron

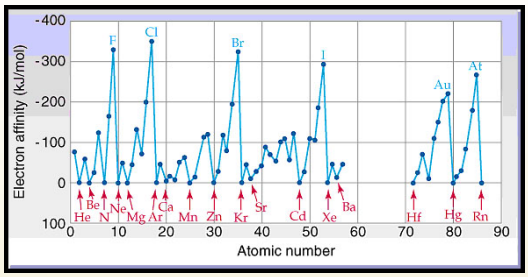
  X ----------> $X^+ + e^-$



Periodic Properties

Electron Affinity

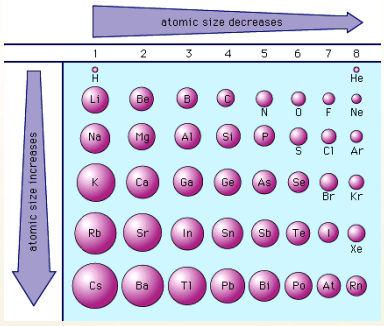
X + e⁻ ---------->X⁻



Periodic Properties

Atomic Size

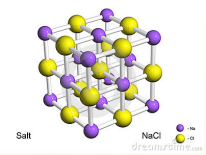
(radius)



Ion Formation

Na ----------> Na^+ + e^-

$1s^2 2s^2 2p^6 3s^1$ $1s^2 2s^2 2p^6$



Cl + e^- ----------> Cl^-

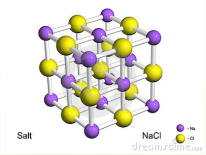
$1s^2 2s^2 2p^6 3s^2 3p^5$ $1s^2 2s^2 2p^6 3s^2 3p^6$

Ion Formation

Na ----------> Na^+ + e^-

$1s^2 2s^2 2p^6 3s^1$ $1s^2 2s^2 2p^6$

isoelectronic with Neon



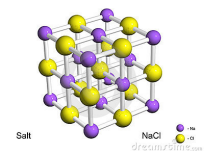
Cl + e^- ----------> Cl^-

$1s^2 2s^2 2p^6 3s^2 3p^5$ $1s^2 2s^2 2p^6 3s^2 3p^6$

isoelectronic with Argon

Ionic Bonding

- Electrons are transferred from a metal to a non-metal
- Held together by strong electrostatic force
- High Melting points



Ionic Bonding

- Metal Non-metal bonds:

Ca^{2+} 2 Cl^{-} -------> $CaCl_2$

Cu^{+} + s^{2-} --------> Cu_2S