

The Periodic Law

Chapter 5

History of PT

- Sept. 1860, First International Congress of Chemists met in Germany
- Presentation done by Stanislao Cannizzaro concerning a method for accurately measuring the relative masses of atoms
- Dmitri Mendeleev (Russian Chemist) decides to write a textbook. Arranged the elements by their atomic mass and observed periodic trends in atomic properties

- Placed elements with similar properties in groups. First table was published in 1869 (see pg 134 for original table)
- 1911 English scientist Henry Moseley examined the spectra of metals. Was able to observe a new trend. Found that the elements best grouped by increasing atomic number.

Periodic Law

- The physical and chemical properties of the elements are periodic functions of their atomic numbers

Modern PT

- An arrangement of the elements in order of their atomic numbers so that elements with similar properties fall in the same column or group
- Important groups:
 - Noble Gases
 - The series (Lanthanides and Actinides)

S block

- Group I: Alkali Metals
 - Include all except H, have one valence electron
 - Silvery, soft metals
 - Never found as free elements in nature
 - Combine vigorously with nonmetals
 - React with water to produce H and aqueous solutions of substances called alkalis
 - Must be stored in kerosene
 - Low melting points

- Group 2: Alkaline Earth Metals
 - 2 valence electrons
 - Harder, denser, and stronger than alkali metals
 - Higher melting points than alkali
 - Less active than alkali, but still never found in free state in nature

D-block

- Groups 3-12
 - Called transitional elements
 - All metals and have typical metallic properties
 - Less reactive than alkali or alkaline earth, some metals in groups least reactive of all metals (ie Au, Pd, and Pt)
 - Typically have 1-3 valence e-

P Block

- Group 13: boron family
 - Have 3 valence electrons
 - Contain metals and nonmetal
- Group 14: Carbon family
 - Have 4 valence electrons
 - Contain nonmetal (C), metalloid (Si and Ge), and metal (Sn, Pb, Uuq)

- **Group 15: Nitrogen family**
 - Have 5 valence electrons
 - Contain nonmetal (N and P), metalloid (As and Sb) and metal (Bi, Uup)
- **Group 16: Oxygen family or Chalcogens**
 - Have 6 valence electrons
 - Contain nonmetal (O, S, Se) metalloids (Te), and metal (Po and Uuo)

- Group 17: Fluorine family or Halogens
 - Have 7 valence electrons
 - Contain nonmetals, most active of all nonmetals. Usually found as diatomic molecules (**BrINClHOF**)
 - React with metals to form salts
- Group 18: Noble or Inert Gases
 - Have 8 valence electrons, except He (only has 2 e-)
 - Contain nonmetals, considered nonreactive

Periodic Properties

- Atomic radii
 - $\frac{1}{2}$ distance between the nuclei of identical atoms that are bonded together
 - Period trend
 - The radii tend to become smaller across the period due to the increased positive charge of the nucleus
 - Also keep in mind get closer to the octet as go across, hold onto e- more tightly

– Group trend

- The atomic radii of the main-group (s and p blocks) elements increase down a group
- This increase due to additional orbitals (rings)
- See page 151, figure 13

Ionization Energy

- The energy required to remove one electron from a neutral atom of an element
 - Ion: an atom or group of bonded atoms that has a positive or negative charge.
 - Any process that results in the formation of an ion is ionization

- Unit of energy is kilojoules per mole (KJ/mol)
- See page 153, figure 15
- Period trend:
 - The ionization energies of the main-group elements increase across each period
 - Due to increase in nuclear charge (closer to octet as move across period)

- Group trend:
 - Among the main-group elements, ionization energies generally decrease down a group
 - Increase distance from nucleus makes it easier to remove an electron

- Removal of first electron uses first ionization energy (IE_1)
- Removal of second electron from same atom called second ionization energy (IE_2)
- Removal of third electron from the same atom called third ionization energy (IE_3) etc...
- Each successive electron removed from an ion has an increasingly stronger effective nuclear charge (more energy is required to remove each successive electron due to the offset of charge of nucleus and e^-) See table 3, page 155

Electron Affinity

- The energy change that occurs when an electron is acquired by a neutral atom
- $A + e^- \rightarrow A^- + \text{energy}$
 - Atom willing to give up energy to receive an additional electron
- $A + e^- + \text{energy} \rightarrow A^-$
 - Atom must be forced to accept an additional electron

- Period trend

- Increase (become more negative as you go across a period)
- Elements are willing to give up more in order to obtain an electron (closer to octet)

- Group trend

- Decrease (become less negative as you go across a period)
- Elements are not willing to give up as much energy due to increased distance between nucleus and electrons

Ionic Radii

- Cations:
 - Period trend
 - Cations get smaller than original atoms
 - Anions get larger than original atoms
 - Group trend
 - Both get larger as go down a group due to increased orbitals

Electronegativity

- A measure of the ability of an atom in a chemical compound to attract electrons from another atom in the compound
- Created by Linus Pauling used a 0-4 scale
4 most likely to acquire, 0 least likely to acquire

See page 161: mark this in book, you need this table frequently

- Period trend:
 - Increase as go across a period (closer to octet)
- Group trend:
 - Decrease as go down a group