Periodic Table and Periodicity

“Orientation in Time and Space”
Review

- Bohr Model 2-D
- Nucleus
- Proton
- Neutron
- Electron
- Atomic Number
- Atomic Mass
- Period
- Group
Heisenberg Uncertainty Principle

- It is impossible to measure accurately both the position and energy of an electron at the same time.
- Proposed a cloud model based on the probability of finding an electron in a certain region of space at any given instant.
Periodicity refers to the recurring trends that are seen in the element properties.
Orientation in Time and Space
Periodicity

Dmitri Mendeleev
(1834-1907)

In 1869 he published the first successful systematic arrangement of the elements. He discovered that if the elements were arranged in order of increasing atomic weight, there was a periodic repetition of chemical and physical properties.
Where do we find the trends?
Periodic Properties

- **Atomic Radius** – half the distance between the centers of two atoms that are touching each other

- **Ionization energy** – energy required to remove an electron from an ion or gaseous atom

- **Electron Affinity** – ability of an atom to accept an electron

- **Electronegativity** – measure of the ability of an atom to form a chemical bond
Atomic Radius

- The atomic radius of an element is half of the distance between the centers of two atoms of that element that are just touching each other.

- Generally, the atomic radius decreases across a period from left to right and increases down a given group.

- The atoms with the largest atomic radii are located in Group I and at the bottom of groups.
**Definition and Characteristic Properties**

- The energy required to completely remove an electron from a gaseous atom or ion.
- The closer and more tightly bound an electron is to the nucleus, the more difficult it will be to remove, and the higher its ionization energy will be.
- Ionization energies increase moving from left to right across a period (decreasing atomic radius). Ionization energy decreases moving down a group (increasing atomic radius).
- Group I elements have low ionization energies because the loss of an electron forms a stable octet.
Electron Affinity

- The ability of an atom to accept an electron

- In a period, the halogen will have the highest electron affinity, while the noble gas will have the lowest electron affinity

- decreases moving down a group because a new electron would be further from the nucleus of a large atom.
Electronegativity

- A measure of the attraction of an atom for the electrons in a chemical bond
- The higher the electronegativity of an atom, the greater its attraction for bonding electrons
- Electronegativity is related to ionization energy. Electrons with low ionization energies have low electronegativity because their nuclei do not exert a strong attractive force on electrons and vice versa
Periodic Table Groups

A closer look at:
* Alkali Metals
* Alkaline Earth Metals
* Transition Metals
* Metalloids
* Halogens
* Noble Gases
Group 1A: Alkali Metals

- Lower densities than other metals \((d = m/v)\)
- One loosely bound valence electron
- Highly reactive
- Form salts with other elements (mostly 7A Halogens)
Group 2A: Alkaline Earth Metals

- Two valence electrons in the outer shell
- Readily form divalent cations
- \( \text{Di} = 2, \text{Valent} = \text{outer shell/orbital} \text{ Cation} = \text{positive charge} \)
Group 3B to 12B: Transition Metals

- Positive Oxidation states (charges – cations)
- Very hard metals
- High melting points
- Low boiling points
- High electrical conductivity
- Malleable
- Five $d$ orbitals become more filled, from left to right on periodic table

Characteristic Properties

Metallic Zirconium (Zr) and Cadmium (Cd)
Group 7A: Halogens

- Seven valence electrons (one short of a stable octet – octet rule)
- Highly reactive, especially with the Group 1A Alkali Metals and Group 2A Alkaline Earth Metals

Characteristic Properties

Metallic Fluorine (F) and Iodine (I)
Group 8A: Noble Gases

- Fairly nonreactive
- Complete valence shell
- Low boiling points (all gases at room temperature)
Lanthanides

- Silvery-white metals that tarnish when exposed to air
- Relatively soft metals
- High melting and boiling points
- Very reactive
- Commonly bind to water
- React with H\(^+\) to release H\(_2\)
- Exothermic reaction with Hydrogen
- Burn easily in air
Actinides

- All are radioactive
- Highly electropositive
- Tarnish readily in air
- React with boiling water or dilute acid to release hydrogen gas
- React with most nonmetals
Is It a Metal, Non-Metal, or Metalloid?
Metal Properties

- Lustrous (shiny)
- Malleable (can be hammered)
- Good conductors of heat and electricity
- These properties result from the ability to easily move the electrons in the outer shells of metal atoms.
Non-Metal Properties

- The nonmetals are poor conductors of heat and electricity
- Solid nonmetals are brittle and lack metallic luster
- Most nonmetals gain electrons easily
- The nonmetals are located on the upper right side of the periodic table, separated from metals by a line that cuts diagonally through the periodic table
- The nonmetals can be divided into classes of elements that have similar properties. The halogens and the noble gases are two groups of nonmetals.
Elements that have some properties of metals and some properties of nonmetals are called metalloids.

- Good semiconductors

- The metalloids are located along the diagonal line between the metals and nonmetals in the periodic table.