

General Chemistry

Chapter 7: Periodic properties of the elements

Review

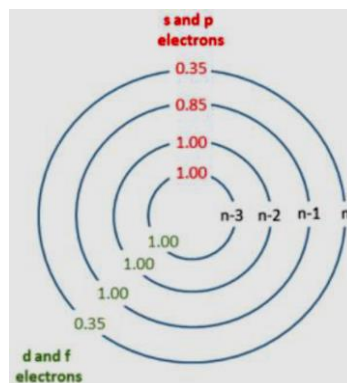
- **Valence orbitals:** the occupied orbitals that hold the electrons involved in bonding.
- **Z_{eff} :** effective nuclear charge. The net positive charge experienced by an electron in a multi-electron atom. $Z_{\text{eff}} = Z - S$ ($Z_{\text{eff}} < Z$)
- **Z:** the actual nuclear charge. The value of Z = the atomic number
- **S:** screening constant
 - 1) Simple method: the value of S equals the number of core electrons.
 - 2) Slater's rules:

A: electrons for which n is larger than the value of n for the electron of interest contribute 0 to the value of S.

B: electrons with the same value of n as the electron of interest contribute 0.35 to the value of S, except for the [1s] group, where the other electron contributes only 0.30.

C: electrons that have principle quantum number $n-1$ contribute 0.85 to the value of S.

D: electrons that have even smaller principle quantum number contribute 1 to the value of S.

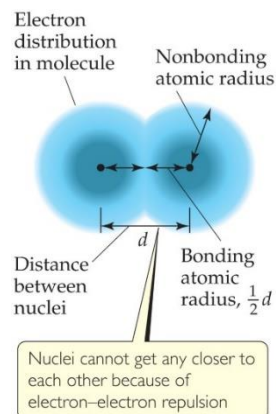


● Trends:

- 1) The effective nuclear charge increase from left to right across any period.
- 2) The effective nuclear charge increase slightly when go down a column.

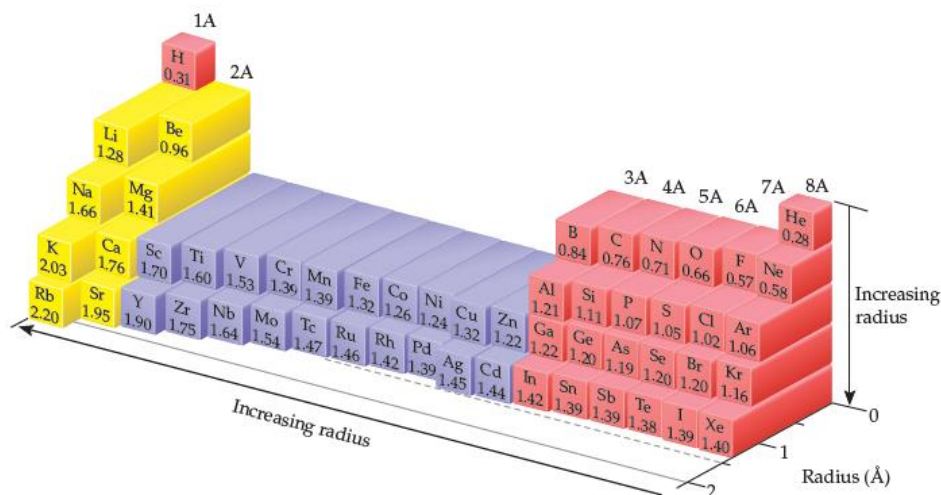
- **Nonbonding atomic radius (van der Waals radius):** half of the shortest distance separating two nuclei during a collision of atoms.
- **Bonding atomic radius (covalent radius):** half the interatomic distance when atoms are bonded.

Unless otherwise noted, we mean the bonding atomic radius when we speak of the "size" of an atom.



● Trends (atomic radii):

- 1) Within each group, bonding atomic radius tends to increase from top to bottom ($n \uparrow$);
- 2) Within each period, bonding atomic radius tends to decrease from left to right ($Z_{\text{eff}} \uparrow$).



- **Properties of metals and nonmetals:**

Metals	Nonmetals
Have a shiny luster; various colors, although most are silvery	Do not have a luster; various colors
Solids are malleable and ductile	Solids are usually brittle; some are hard, and some are soft
Good conductors of heat and electricity	Poor conductors of heat and electricity
Most metal oxides are ionic solids that are basic	Most nonmetal oxides are molecular substances that form acidic solutions
Tend to form cations in aqueous solution	Tend to form anions or oxyanions in aqueous solution

- **Metals:**

- 1) Metals tend to have low ionization energies and therefore tend to form cations relatively easily;
- 2) Compounds made up of a metal and a nonmetal tend to be ionic substances;
- 3) **Most metal oxide are basic;**

- **Nonmetals:**

- 1) **Because of their relatively large, negative electron affinities, nonmetals tend to gain electrons when they react with metals;**
- 2) Compounds composed entirely of nonmetals are typically molecular substances that tend to be gases, liquids or low melting solids at room temperature;
- 3) **Most nonmetal oxides are acidic;**

- **Metalloids:** Metalloids have properties intermediate between those of metals and those of nonmetals.

- **Alkali metals:**

- 1) Soft metallic solids, silvery, metallic luster, high thermal and electrical conductivity, low density, low melting point;
- 2) React with hydrogen to form hydrides and with sulfur to form sulfides;
- 3) React vigorously with water, producing hydrogen gas and a solution of an alkali metal hydroxide;
- 4) Li metal reacts with oxygen to form lithium oxide; Na reacts with oxygen to form sodium peroxide; K/Rb/Cs react with oxygen to form K/Rb/Cs superoxide;

- **Alkaline earth metals:**

- 1) Solid at room temperature, harder and denser and melt at higher temperature (compared with alkali metals);
- 2) **The first ionization energies of the alkaline earth metals are low but not as low as alkali metals, so the alkaline earth metals are less reactive than alkali metals;**
- 3) **Beryllium doesn't react with water and steam, even when heated red-hot;**
- 4) Magnesium reacts slowly with liquid water and more readily with steam;
- 5) Calcium and the elements below it react readily with water at room temperature;

- **Hydrogen:**

- 1) Hydrogen is a nonmetal that occurs as colorless diatomic gas under most conditions;
- 2) Hydrogen react with most nonmetals to form molecular compounds in which its electron is shared with other nonmetal;
- 3) Hydrogen readily form H^+ ions in which the hydrogen atom has lost its electron;
- 4) The ability of molecular compounds of hydrogen with nonmetals to form acids in water;

5) Hydrogen has the ability to gain electron from a metal with a low ionization energy;

- **The Oxygen Group:**

1) Oxygen: nonmetal, a colorless gas at room temperature, exist in two molecular forms, O₂ and O₃;

2) Sulfur: nonmetal, exist in several allotropic forms, the most common and stable form is S₈ rings;

3) Selenium: nonmetal, essential for life but toxic at high doses;

4) Tellurium: metalloid, elemental structure is more complicated;

5) Polonium: metal, radioactive;

- **The Halogen:**

1) the halogens are typical nonmetals;

2) highly negative electron affinities, F and Cl are more reactive than Br and I;

3) react directly with metals to form metal halides;

- **The Noble Gases:**

1) they have very large ionization energies;

2) their electron affinities are positive;

3) they are found as monatomic gases;

4) they completely filled *s* and *p* subshells