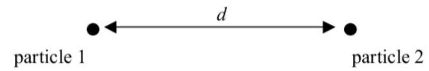
Periodicity

Chemistry 30 AP – Ms. Hayduk

Coulomb's Law



charge on particle 1 = q_1

charge on particle 2 = q_2

$$F = \frac{kq_1q_2}{d^2}$$

Coulomb's Law

- Measure of electromagnetic forces (attractive/repulsive forces between electrically-charged or magnetic objects
- Force of attraction depends on magnitude of nuclear charge (+) and electron
- Increases as:
  - Nuclear charge increases
  - Electron moves closer to nucleus

Effective Nuclear Charge

- Electrons are both attracted to nucleus and repelled by other electrons
- $\mathbf{Z_{eff}}$: net charge on a single electron, considering the electric field from other electrons and positive nuclear charge

Effective Nuclear Charge

$$Z_{eff} = Z - S$$

- Z is the number of protons in the nucleus
- S is the screening constant, usually close to the number of core electrons

What does this mean?

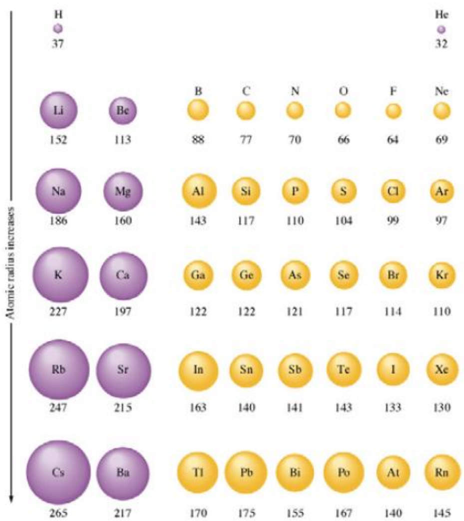
- Greater attraction when the nucleus is <u>larger</u>, but the number of core electrons stays the same

Rules for Periodic Trends

1. Z_{eff} – more positive nucleus means more attractive force drawing electrons in and holding them in place
2. Distance – attractive forces decrease as electrons are further away from the nucleus
3. Shielding – core electrons shield outer electrons from nucleus' attractive force (down, not across)
4. Minimize electron/electron repulsions

Atomic Radius

- Distance from the center of the nucleus to the outermost occupied energy level
- No sharp boundary!
- Decreases across a period
  - Higher Z_{eff}, larger nucleus with same energy levels, so electrons are more attracted more strongly and cloud "shrinks"
- Increases down a group
  - Principal level determines size of atom, so distance decreases attraction



Example: Atomic Radius

Arrange the following in order of increasing atomic radius: F, P, S, As.

Ionic Radius

- **Isoelectronic** – ions with the same ground state configuration
- Cations – smaller than atom, since nucleus is attracting fewer electrons
- Anions – larger than atom, since nucleus is attracting more electrons
- Must consider change in electron repulsion when considering size

Example 1: Ionic Radius

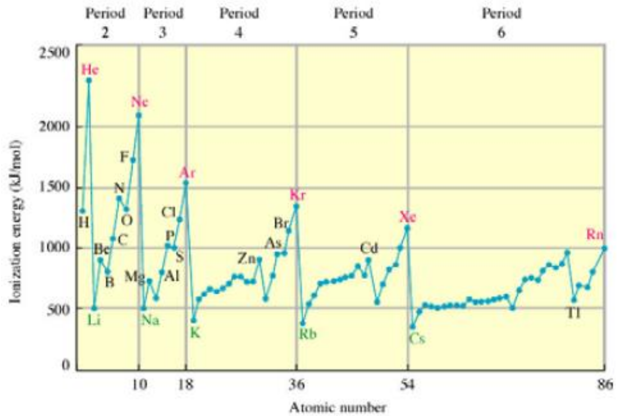
Write the electron configurations for a potassium ion, argon atom and magnesium ion. Which species are isoelectronic?

Example 2: Ionic Radius

Arrange in order of increasing size: P^{3-}, K^{+}, Cl^{-}

Ionization Energy

- Energy required to remove an electron from the atom in the gas phase (forming a cation)
- Harder to remove subsequent electrons, (especially if they are from another sublevel (s, p, d, f) or energy level (n)
- Decreases down a group
  - Increased distance from nucleus, increased shielding by core electrons
- Increases across a period
  - Increased Z_{eff} – stronger attraction to nucleus



Ionization Energy

Anomalies:

1. Drops from s^2 to p^1, because p orbital is slightly further from the nucleus than s (2A to 3A)
2. Drops between 5A and 6A, because 6A has the first paired electron in p, increasing electron repulsion and making that electron slightly easier to remove

Electron Affinity

- Energy associated with adding an electron to a gaseous atom (forming an anion)
- Negative EA means anion is stable (following thermo conventions)
- More negative across period, except for noble gases
- Minimal change within a group