Ch 7 Periodic Trends AP Chemistry

Learning objective 1.6 The student is able to analyze data relating to electron energies for patterns and relationships. [See SP 5.1; Essential knowledge 1.B.1]
Learning objective 1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. [See SP 6.4; Essential knowledge 1.C.1]
Learning objective 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity. [See SP 6.1; Essential knowledge 1.C.1]
| **Learning objective 1.11** The student can analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied. [See SP 3.1, 5.1; Essential knowledge 1.C.1]

Periodic Trends and Key Terms

Atomic Radius: Across a period- **ENC (Shielding Effect and Nuclear Charge),** down a group- increased **n**
Atomic radius refers to the distance between the nucleus and the outer edge of the electron cloud. It is influenced by the nuclear pull and the number of energy levels. **Across a Period:** Atomic radii decrease as atomic numbers increase in any given period
DO Greater effective nuclear charge, **Zeff, increases the attractive force of the nucleus** and therefore pulls the electron cloud closer to the nucleus resulting in a smaller atomic radius **across the period**. Full energy levels provide shielding between the nucleus and valence electrons, thus within a period, the effective nuclear charge, Zeff, is somewhat constant. **Don't** use shielding for explanations across a period. Only full energy levels, not full sublevels, are of concern in a shielding argument.
Down a Group: Atomic radii increase as atomic number increases down a group **Increased number of energy levels (n) increases** the distance over which the nucleus must attract and therefore reduces the attraction for electrons **DON'T** simply stating that atomic radii decrease from left to right across a period or that radii increase down a column.

Ionic Radius Same as Atomic Radius

Ionization Energy: ENC and location of e being removed
Ionization energy refers to the energy needed to remove an electron from a gaseous atom or ion, i.e. an isolated one, not part of a solid, liquid or a molecule. It is always endothermic.
Across a Period: Ionization energy increases as atomic number increases in any given period **DO** Greater effective nuclear charge, **Zeff, increases the attractive force** of the nucleus and therefore holds the electrons more tightly. **Don't** simply stating that ionization energy increases from left to right across a period.

Down a Group: Increased **number of energy levels (n)** increases the distance over which the nucleus must pull and therefore reduces the Coulombic (electrostatic) attraction for electrons.

Exceptions Exceptions in IE : Between 2nd and 3rd group- lesser penetration of p e in the nuclear region, between 13 and 14 group- e-e repulsion between paired e
1) A drop in IE occurs between groups II and III because the p electrons do not penetrate the nuclear region as greatly as s electrons do and are therefore not as tightly held. Don't state that p electrons are farther away from the nucleus.
2) A drop in IE occurs between groups V and VI because the increased repulsion created by the first pairing of electrons in the p-orbitals outweighs the increase in Zeff and thus less energy is required to remove the electron. Don't state that the atoms in group V are more stable because they have a half filled sublevel.

Electron Affinity: Coulomb's Law

Electronegativity: Coulomb's Law

Electronegativity is an assigned property which indicates the attraction of an atom for the pair of outer shell electrons in a covalent bond with another atom. Electronegativity patterns are the same as electron affinity patterns for the same reasons. Both of these properties focus on the attraction that the nucleus has for electrons. This attraction is based on coulombic attraction between nuclear protons and electrons.
Across a Period: Electronegativity increases as atomic numbers increase in any given period

Metallic Character: Ease of losing e (larger atoms, lesser ENC, easy to lose outermost e)

Practice Problems

#1.

	First ionization Energy (kilocalories/mole)	Covalent Radii, Å
Li	124	1.34
Be	215	0.90
B	191	0.82
C	260	0.77
N	336	0.75
O	314	0.73
F	402	0.72

The covalent radii decrease regularly from Li to F, whereas the first ionization energies do not. For the ionization energies, show how currently accepted theoretical concepts can be used to explain the general trend and the two discontinuities.

#2. $M(s) + Cl_2(g) \rightarrow MCl_2(s)$

The reaction of a metal with chlorine proceeds as indicated above. Indicate, with reasons for your answers, the effect of the following factors on the heat of reaction for this reaction.

(a) A large radius versus a small radius for M^{2+}
(b) A high ionization energy versus a low ionization energy for M.

#3 The electron affinities of five elements are given below.

$_{13}$Al 12 kcal/mole
$_{14}$Si 32 kcal/mole
$_{15}$P 17 kcal/mole
$_{16}$S 48 kcal/mole
$_{17}$Cl 87 kcal/mole

Define the term "electron affinity" of an atom. For the elements listed above, explain the observed trend with the increase in atomic number. Account for the discontinuity that occurs at phosphorus.

#4. Removal of each successive electron from the same atom in the ionization process takes increasing amounts of energy. However, at some point in the process there is a considerable **jump** in how the ionization energy increases. At what step in the ionization process would you expect magnesium to exhibit a sudden marked increase in its ionization energy? Why?

a. The first ionization
b. The second ionization
c. The third ionization
d. The fourth ionization
e. The fifth ionization

#5. Which of the elements of the fourth period has the smallest atomic radius?

a. K
b. Sc
c. Zn
d. Ga
e. Cr

#6. Atom of which elements are diamagnetic?

a. Ca
b. N
c. Sc
d. Cl
e. O