Week 8/Tu: Lecture Unit ‘19’

Unit 18: Periodicity
-- electron configurations
-- periodicity of elements
-- radii, ionization, affinity
-- electronegativity

Unit 19: Chemical Bonding
-- Basis of bonding
-- Ionic Bonds
-- Electron sharing, Covalent

Unit 20: Covalent Bonding
-- Lewis Dots
-- multiple bonds
-- Lewis “structures”

Issues: ?

Homework #6 due this Saturday, Oct. 20th 8am
Exam #2 on next Monday, Oct. 22, 7:15pm !!
★ Tuesday, October 16th, 6 - 8:30pm in N100 BCC  
(LRC Mock Exam, reservation required!)

★ Thursday, October 18th, 6 - 8:30pm in N100 BCC  
(LRC Q&A Review Session)

★ Sunday, October 21st, 4 - 6pm in 138 Chemistry  
(Dr. Pollock)

★ Monday, October 22nd, 7:15 PM, EXAM for everyone

★ Tuesday, October 23rd, back here for lecture 11:20am
Li (s) + air $\rightarrow$ [not much happens in a short time, depends on humidity]

Li (s) + H$_2$O (l) $\rightarrow$ Base (aq) + “burning” + $\Delta$H – (exothermic)
We have seen already that the electrons in each atom are bound to the nucleus and the amount of binding varies depending on the atomic number and the electron orbitals being filled.

What would we expect if two atoms came into contact?

If the atoms are not the same element then we might expect that the outermost electrons (valence) will have different energies and there will be a tendency for electrons to move over to the lower energy state.

However, the nucleus with electrons in the higher energy state will continue to exert an attractive force on those electrons; pull them back.

Thus, there is an automatic mechanism for electron sharing when atoms come in contact with one-another.
Recall that each atom binds the number of electrons equal to its atomic number. The First Ionization Energy is always positive and generally large. The amount of the binding (ionization energy) changes with the energy level being filled and with the number of electrons already in a given level.

Recall also that the amount of energy emitted (electron affinity) when an atom gains an electron is usually small but is strongly dependent on the filling pattern of the electrons.

The **electronegativity** reflects these two energies to indicate the relative ability of an atom to “attract electrons” to itself in a compound.
We can use Pauling’s electronegativity scale to estimate the degree of sharing of electrons between atoms that we might expect by taking the difference between the two values.

Largest $\Delta\chi$
FrF $\rightarrow$ 3.3

NaO $\rightarrow$ 2.6  
[in Na$_2$O]

HO $\rightarrow$ 1.4  
[in H$_2$O]

Smallest $\Delta\chi$
(many metals) $\rightarrow$ $\sim$0  
(obvious case same atoms)
A few combinations of elements that are predicted to have very unequal sharing of electrons – these come from the situations where the valence energy levels are very different in energy. Actual electron transfer – *Ionic solids*

Most combinations of elements have an unequal sharing of valence electrons. No electron transfer – *Covalent molecules*

Combinations of metals tend to have very small differences in energy levels. Electrons shared widely – *Metallic solids*
Na\(^+\) + e\(^-\) \rightarrow (g) + Cl \((g)\) \[\Delta H = -349 \text{ kJ}\]

1\(^{\text{st}}\) Ionization

Na \((g)\) + Cl \((g)\) \[\Delta H = +119 \text{ kJ}\]

Bond Dissociation of Cl\(_2\)

Na \((g)\) + \(\frac{1}{2}\) Cl\(_2\) \((g)\) \[\Delta H = +108 \text{ kJ}\]

Sublimation

Na \((s)\) + \(\frac{1}{2}\) Cl\(_2\) \((g)\) \rightarrow NaCl \((s)\) + \(\Delta H_f^\circ\) = -411 kJ

\(\Delta H_f^\circ = -411 \text{ kJ}\)

Electron Affinity of Cl

\(\Delta H = +108 \text{ kJ}\)

Sublimation

\(\Delta H = +496 \text{ kJ}\)

1\(^{\text{st}}\) Ionization

\(\Delta H = +119 \text{ kJ}\)

Bond Dissociation of Cl\(_2\)

\(\Delta H = -787 \text{ kJ}\)

Lattice Energy of NaCl
Week 8/Tu: Best Case for Electron Transfer

\[ \text{Cs}^+ + e^- (g) + \text{Cl} (g) \rightarrow \text{CsCl} (s) \quad \Delta H = -349 \text{ kJ} \]

Electron Affinity of Cl

\[ \text{Cs} (g) + \frac{1}{2} \text{Cl}_2 (g) \rightarrow \text{Cs}^+ (g) + \text{Cl}^- (g) \quad \Delta H = +119 \text{ kJ} \]

Bond Dissociation of \( \text{Cl}_2 \)

\[ \text{Cs} (s) + \frac{1}{2} \text{Cl}_2 (g) \rightarrow \text{CsCl} (s) \quad \Delta H = +76 \text{ kJ} \]

Sublimation

\[ \text{Cs} (s) + \frac{1}{2} \text{Cl}_2 (g) \rightarrow \text{CsCl} (s) + \Delta H_f^o = -443 \text{ kJ} \]
Almost 100 years ago in 1916 and before quantum mechanics was developed, G.N. Lewis created a theory of electron-pair bonds (even before the electron spin was observed in 1925).

1) Valence electrons are shared in pairs between atoms.
2) The number of electrons available to each atom in the bond should be the same as the number of electrons in the next noble gas (usually 8).

Note: For the S and P Block elements, there are only 8 valence arrangements of electrons on the atoms.
The tremendous power and simplicity of the Lewis theory allows it to be very useful today, and provides insight into chemical bonding. Some people use “dots” and “ex’s” but all electrons are identical…

H valence shell needs 2

\[
\text{H} \cdot + \text{xH} \rightarrow \text{H} : \text{H}
\]

F valence shell needs 8

\[
\text{xF} \cdot + \text{xF} \rightarrow \text{xF} : \text{xF}
\]

NOTE: similar for Cl₂, Br₂, I₂, At₂, ClF, BrF, etc. thus, the Lewis theory explains “chemical groups” and periodicity.