Name: ____ Date: _____________________ CHEM 1A

Monday/Tuesday, November 25 & 26, 2019 -Bonding (All Chapter 13)

I. Recall – Types of Bonding - What is the difference between an ionic bond and a covalent bond?

Ionic Bonds – the compound is then held together by electrostatic attraction between the ions. Usually between a metal and a nonmental.

Covalent Bonds - Formed when the lowest energy structure can be achieved by sharing electrons. Usually between nonmetals.

1. Which of the following elements forms the most ionic bond with chlorine?
(A) Rb (B) Ga (C) N (D) Ar (E) I

2. Which of the following groups contains no ionic compounds? (A) HCN, SO_2, $Ca(NO_3)_2$
(B) PCl_5, LiBr, $Cu(OH)_2$ (C) NaOH, CBr_4, SF_4 (D) NaH, CaF_2, $NaNH_2$ (E)CH_4O, H_2O, NBr_3

3. Which of the following series is isoelectronic? Isoelectronic = same electron config.
(A) B, C, N, O (B) S^{2-}, Cl^-, K^+, Ca^{2+} (C) F^-, Cl^-, K^+, Rb^+ (D) Na, K, Rb, Cs (E) Sn, As, S, F

4. Order the following ions in size from smallest to largest: S^{2-}, Cl^-, K^+, Ca^{2+}, Al^{3+}, Te^{2-} (Hint: Remember effective nuclear charge and how it affects atomic radii). $Al^{3+} < Ca^{2+} < K+ < Cl^- < S^{2-} < Te^{2-}$

II. The Energetics of Bonding

5. (a) Draw Born-Haber cycle for the formation of strontium chloride.

$$Sr(s) \xrightarrow{\text{heat of sublimation}} Sr(g) \xrightarrow{IE_1} Sr^+ \xrightarrow{IE_2} Sr^{2+} \xrightarrow{\text{lattice energy}} SrCl_2(s)$$

$$Cl_2(g) \xrightarrow{\text{heat of bond dissociation}} 2Cl(g) \xrightarrow{EA+2e^-} Cl^-$$

$$\xrightarrow{\text{heat of formation}}$$

(b) Use the following data to calculate the enthalpy of formation of strontium chloride. Write all thermo chemical equations for the steps of the cycle.

The enthalpy of sublimation of strontium = + 164 kJ/mol $Sr(s) \rightarrow Sr(g)$ $\Delta H_{sub} = +164\ kJ/mol$

First ionization energy for strontium = + 549 kJ/mol $Sr(g) \rightarrow Sr^+$ $IE_1 = +549\ kJ/mol$

Second ionization energy for strontium = + 1064 kJ/mol $Sr^+(g) \rightarrow Sr^{+2}$ $IE_2 = +1064\ kJ/mol$

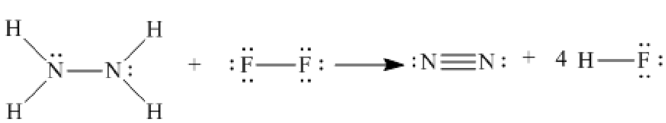
The enthalpy of dissociation of chlorine, Cl_2 = + 243 kJ/mol $Cl_2(g) \rightarrow 2Cl(g)$ $BE = +243\ kJ/mol$

The electron affinity of chlorine, Cl = - 349 kJ/mol $2Cl + 2e^- \rightarrow 2Cl^-$ $EA = 2(-349\ \frac{kJ}{mol})$

Lattice energy of strontium chloride = - 2150 kJ/mol $Sr^{2+} + 2Cl^- \rightarrow SrCl_2(s)$ $LE = -2150\ kJ/mol$

You can use Coulomb's law to verify if you want… Heat of formation = - 828 kJ/mol

6. Estimate the value of ΔH for the following reaction:



Bond	Ave. Bond Energy (kJ/mol)
N–H	391
N–N	160
N=N	418
N≡N	941
F–F	154
H–F	565

ΔH_{est} = Σ BDE reactants - Σ BDE products

ΔH_{est} = [4 mol N-H (391 kJ/mol) + 1 mol N-N(160 kJ/mol) + 1mol F-F(154kJ/mol] – [1 mol N≡N (941 kJ/mol) + 4 mol H-F(565 kJ/mol)]

ΔH_{est} = - 1323 kJ

III. Electronegativity & Molecular Polarity

0 ----------------------------0.4 ----------------------------1.8

Nonpolar Covalent **Polar Covalent** **<** **Ionic**

1. Which of the following is ranked correctly in order of increasing electronegativity:
(A) Cl < Br < I (B) Al < Si < P (C) Li < Na < K

2. Rank the following bonds in order of increasing polarity.
I. C–O II. C–N III. C–F II < I < III

3. As a general pattern, electronegativity is inversely related to
(A) ionization energy. (B) atomic size (C) polarity of the atom. (D) the number of neutrons in the nucleus.

4. In the gaseous phase, which of the following diatomic molecules would be the most polar?
(A) CsF (B) CsCl (C) NaCl (D) NaF (E) LiF

Electronegativity (χ): The ability of an atom to attract electrons to itself when it is part of a compound

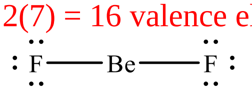
Electric Dipole: A positive charge next to an equal but opposite negative charge.

Polarizability (*α*): The ease with which the electron cloud of a molecule can be distorted. Cations are polarizing; anions are polarizable.

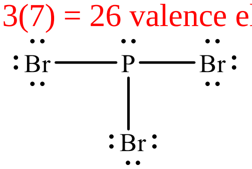
IV. Drawing Lewis Structures

1. Draw Lewis Structures for the following compounds.

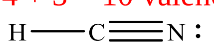
a. BeF_2 ⇒ 2 + 2(7) = 16 valence electrons



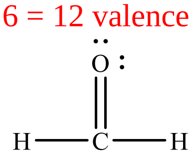
b. PBr_3 ⇒ 5 + 3(7) = 26 valence electrons



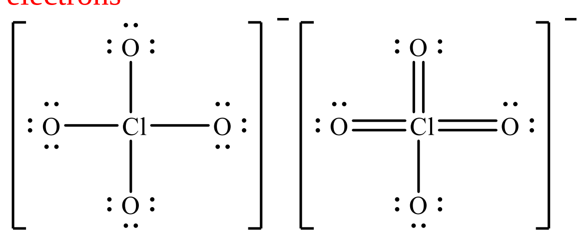
c. HCN ⇒ 1 + 4 + 5 = 10 valence electrons



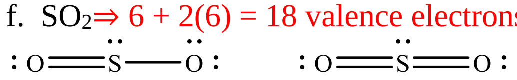
d. H_2CO ⇒ 2(1) + 4 + 6 = 12 valence electrons



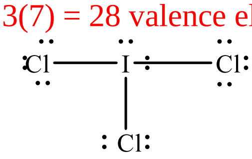
e. ClO_4^- ⇒ 7 + 4(6) + 1 = 32 valence electrons



f. SO_2 ⇒ 6 + 2(6) = 18 valence electrons



g. ICl_3 ⇒ 7 + 3(7) = 28 valence electrons

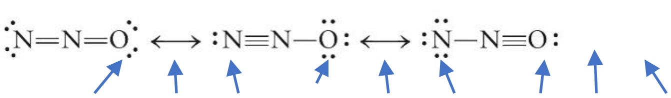


2. For all the structures in IV-1, determine if formal charge can be minimized and draw the structure.

Only e and f. See the structures above.

Resonance: A blend of Lewis structures into a single composite hybrid structure.

3. Which of the following resonance contributors for N_2O is the most stable?



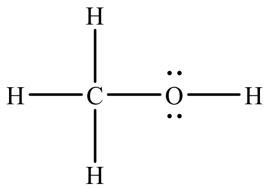
-1 +1 0 0 +1 -1 -2 +1 +1

The middle structure is the most stable because it has minimum FC and the negative FC is on the most EN atom

V. Bond Strength & Length

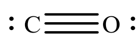
4. Rank the following in order of shortest to longest carbon oxygen bond length: $CO < CO_2 < CO_3^{2-} < CH_3OH$

CH_3OH



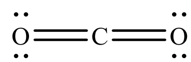
Bond order = 1

CO



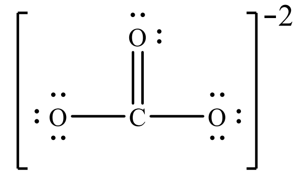
Bond order = 3

CO_2



Bond order = 2

CO_3^{2-}

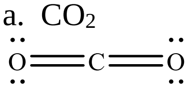


Bond order = 3/2

VI. VSEPR Theory

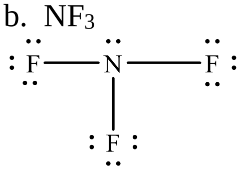
5. Determine the molecular geometry and bond angle for the following:

a. CO_2



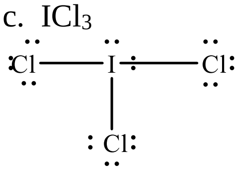
Linear – 180°

b. NF_3



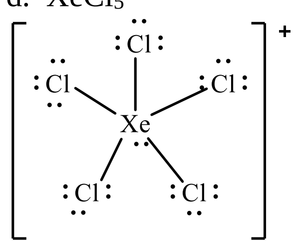
Trigonal pyramid - <109.5°

c. ICl_3



See-saw - <90°

d. $XeCl_5^+$



square pyramid - <90°

6. Which of the following are polar? Circle all that apply

a. BF_3 b. NH_3 c. CCl_4 d. $XeBr_4$ e. H_2CO

7. Go back and determine the molecular geometry & polarity of the molecules in question IV-1.

Lewis Structure Guidelines:

1. Determine the number of valence electrons (group number, add electrons for anions or subtract electrons for cations)
2. Determine the central atom(s) – least electronegative element (exception - hydrogen will not be the central atom)
3. Draw out structure with single bonds symmetrically – add square brackets and charge for ions
4. Put 6 electrons (3 pairs) on each outer atom except hydrogen – put any remaining electrons on the central atom
5. Determine if all atoms have what they want (H ⇒ 2, Be ⇒ 4, B and Al ⇒ 6, and all else ⇒ 8) – if yes you're done – if not add a bond for every 2e- that's missing – the bonding electrons come from an adjacent atoms non-bonded pair – if there's more than one outer atom with lone pairs to share with the central is called resonance – the real structure is a hybrid of the possible resonance structures
6. Formal Charge = Group number – #bonds – #non-bonded electrons
7. Minimizing formal charge ⇒ only possible for molecules with a central atom in period > 2 ⇒ add a double bond between an outer negative atom and a positive central atom