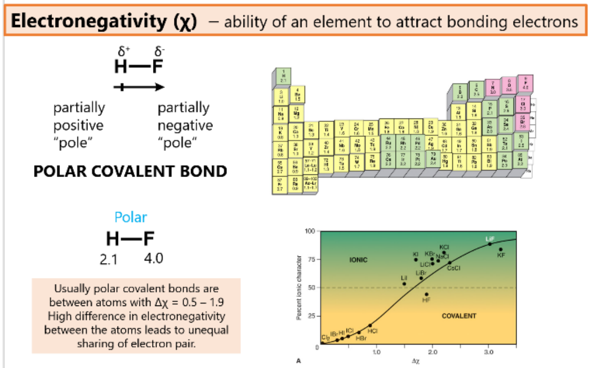
Electronegativity and Lewis Structure Practice

ELECTRONEGATIVITY



LEWIS STRUCTURE:

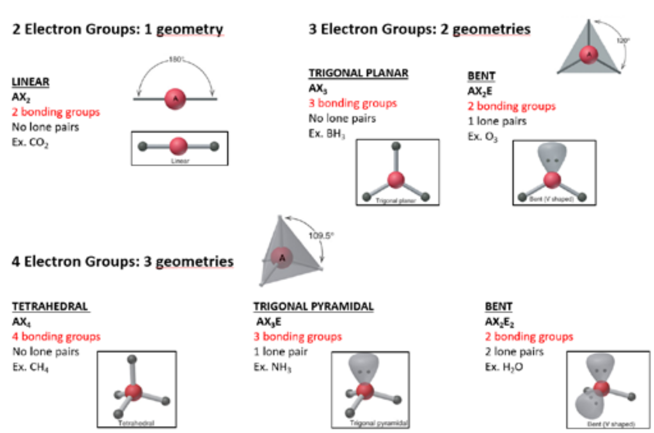
1.Determine total number of valence electrons
2. Any charges? YES – add (-ve charge)/subtract (+ve charge)
3. Build skeleton structure (incomplete Lewis Structure)
4. Group 14,15,16 atoms usually "central"
5. Hydrogen and Group 17 atoms "terminal"
6. Make multiple bonds only when necessary
7. Check - Noble gas electronic configuration at each atom?

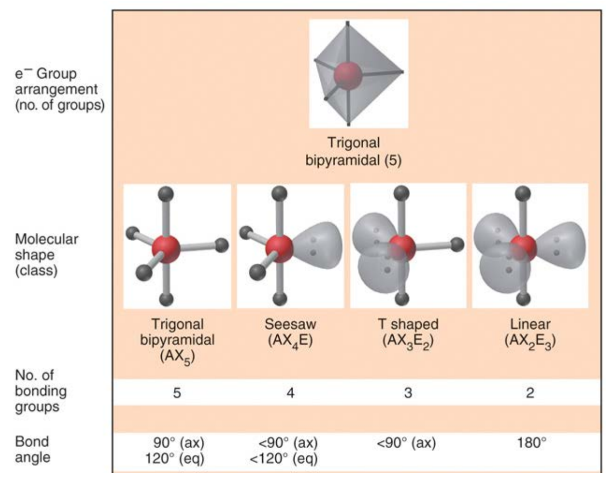
CALCULATING FORMAL CHARGE:

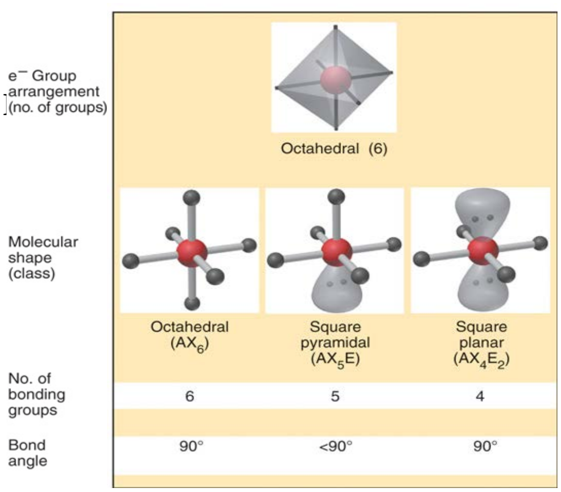
1) Draw Lewis Structure
2) Determine neutral valence of each atom (number of valence electrons)
3) Assign each atom half of bonding electrons + lone pairs
4) FC = Neutral Valence – Assigned electrons

Shape of Molecules (Only electron groups 2, 3, and 4)

VSEPR (Valence Shell Electron Pair Repulsion) Theory



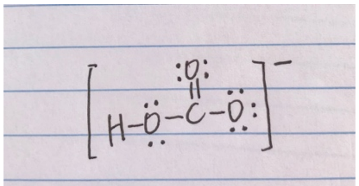




Review

Question 1

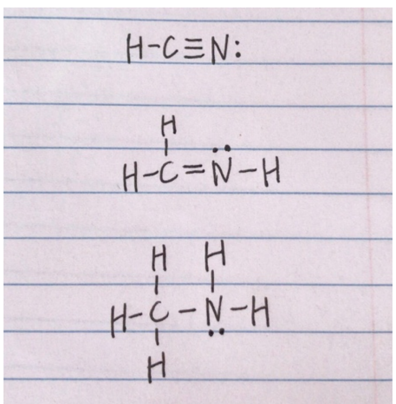
A. Draw the Lewis Structure and identify the formal charge on carbon in the bicarbonate ion $(HCO_3)^-$. Show calculation for the formal charge.



Formal charge on C=valence e^- - (lone pair e^- +$\frac{1}{2}$ bonding e^-)= 4-(0+$\frac{1}{2}$×8)= 0

B. Draw the Lewis structure for HCN, CH_2NH, and CH_3NH_2. (Note: All contain a Carbon-Nitrogen bond)

Which molecule to you expect to have the shortest nitrogen-to-carbon bond? Why?



HCN is expected to have the shortest nitrogen-to-carbon bonds. Because the nitrogen-to-carbon bond in HCN is a triple bond and is the strongest. The stronger the bond, the shorter the bond length.

Question 2

Arrange the following (Explain your answer – show Lewis structures and geometry where applicable)

1. From lowest to highest bond angle

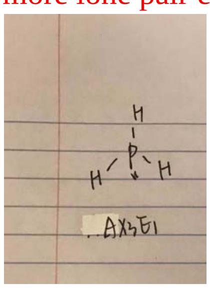
   PH_3, ClO_4^-, SCl_2

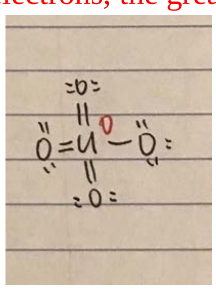
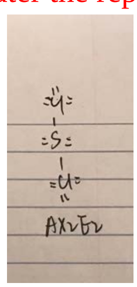
   $SCl_2 < PH_3 < ClO_4^-$

   PH_3 has an electron-group arrangement of AX_3E_1, the bond angle will be smaller than ideal(109.5) due to the presence of a lone pair electron.

   ClO_4^- has an electron-group arrangement of AX_4, and has the ideal bond angle of 109.5 (even though one of the bonds is a single bond and others double bond – there are equally contributing resonance structures so overall all the bond angles will be equivalent)

   SCl_2 has an electron-group arrangement of AX_2E_2, the bond angle will be smaller than that of PH_3 due to the presence of two lone pair electrons instead of one. The more lone pair electrons, the greater the repulsion, and the smaller the bond angle.



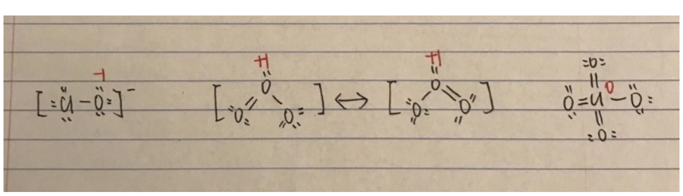



2. From lowest to highest formal charge on the atom that is bolded (consider the most stable Lewis structure only)

   Cl**O**$^-$, **O$_3$** (central oxygen atom), **Cl**O_4^-

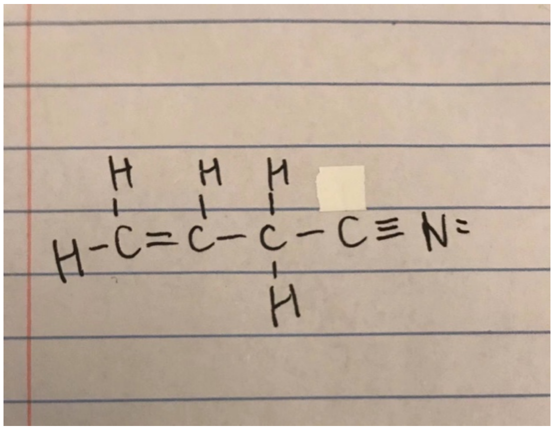
For ClO^- the most stable Lewis structure would have the –ve formal charge on the more electronegative atom (O in this case)

Cl**O**$^-$ < **Cl**O_4^- < **O$_3$**

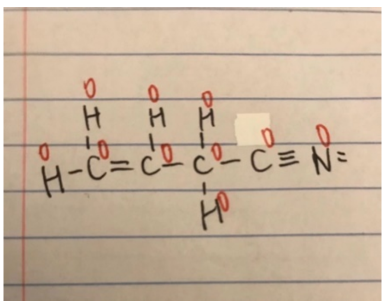


Question 3

a) Draw the Lewis structure(s) for [CH_2CHCH_2CN]. The molecule has a C-C-C-C-N skeleton. Include lone pairs in your answer.



b) Calculate formal charge for N in the structure(s) drawn.



c) Indicate electron groups and the molecular geometry around each carbon.

from left to right:

C1: three bonding electron groups, trigonal planar geometry.

C2: three bonding electron groups, trigonal planar geometry.

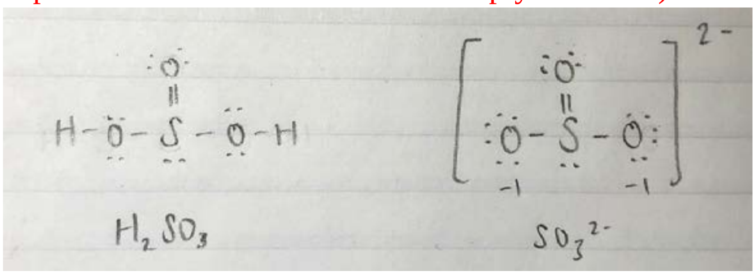
C3: four bonding electron groups, tetrahedral geometry.

C4: two binding electron groups, linear geometry.

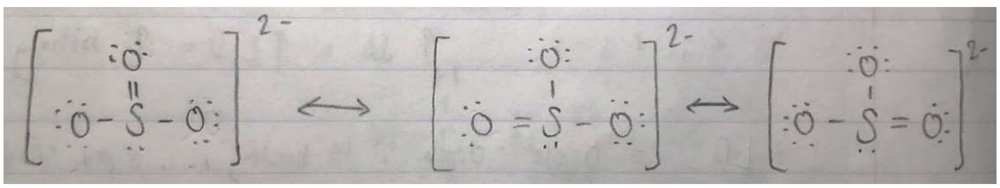
Note: electron group: single bond, double bond, triple bond, lone pair, or even lone electron.

Question 4

a) Draw the Lewis structure(s) for H_2SO_3 and SO_3^{2-}. Include lone pairs in your answer. Indicate all **non zero** formal charge on the atoms.
(Sulphur can expand its octet – is in the 3rd period. Elements in period 3 and below, can expand their octet due to available empty d orbitals)

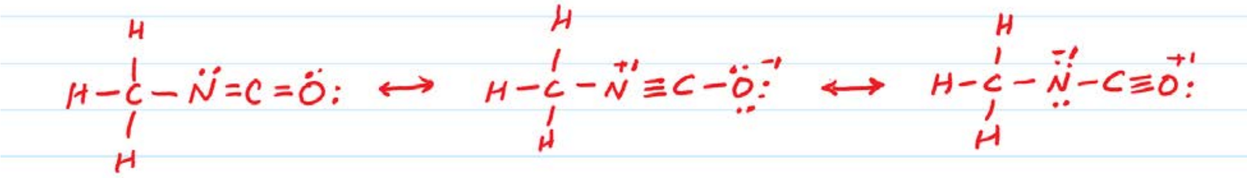


b) Which of the two (H_2SO_3 or SO_3^{2-}) has equivalent resonance structures? Show all equivalent resonance structures for that molecule



Question 5

a. Draw all possible resonance structures for CH_3NCO.



a. Give the formal charge on each atom with a non-zero formal charge.

Formal charges given above the structures:

All formal charges 0 in structure 1

Formal charge on N in structure 2 = valence electrons – assigned electrons = 5 – 4 (4 bonded electrons = 4)= +1

Formal charge on O in structure 2 = valence electrons – assigned electrons = 6 – 7 (3 lone pairs = 3 x 2 = 6; 1 bond =1; 6+ 1 = 7) = +1

Formal charge on N in structure 3 = valence electrons – assigned electrons = 5 – 6 (2 bonded electrons = 2; + 2 lone pairs = 4; 2 + 4 = 6)= -1

Formal charge on O in structure 3 = valence electrons – assigned electrons = 6 – 5 (1 lone pairs = = 2; + 3 bond =3; 2+ 3 = 5) = +1

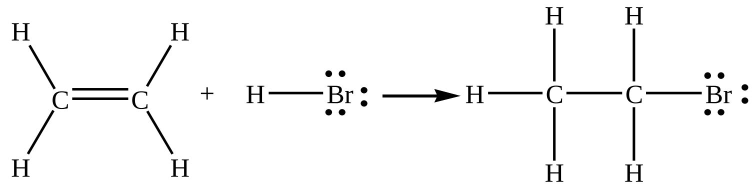
b. Which of the resonance structures is most contributing? Explain why?

Structure 1 is most contributing as the formal charges on all atoms are 0.

Question 6

$C_2H_4 + HBr \rightarrow C_2H_5Br$

In the above reaction, determine the shape of the molecule (around either of the carbons atom) in the reactant and compare that to the shape of the product.



In the reactant:

Both carbons have 3 electron groups and all are bonded: (2 single bonds + 1 double bond) – trigonal planar

In the product:

Both carbons have 4 electron groups and all are bonded: (4 single bonds) – tetrahedral

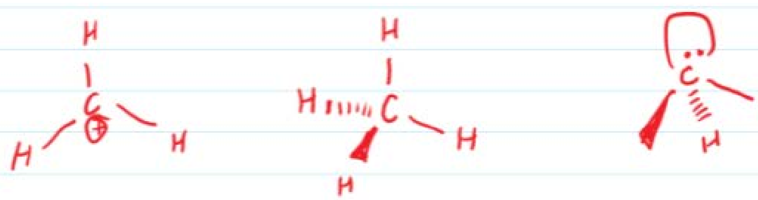
Question 7

For each of the following compare the electron geometry (total electron groups) and molecular geometry (shape of the molecule) around:

a. Central oxygen atom for : H_3O^+ ; OH^-; H_2O

ELECTRON GEOMETRY	TETRAHEDRAL	TETRAHEDRAL	TETRAHEDRAL
MOL. GEOMETRY	TRIGONAL PYRAMIDAL	BENT	LINEAR (2ATOMS ONLY)

b. Central carbon atom for: CH_3^+ ; CH_4; CH_3^-



ELECTRON GEOM	TRIG. PLANAR	TETRAHEDRAL	TETRAHEDRAL
MOL. GEOM.	TRIG. PLANAR	TETRAHEDRAL	TRIG. PYRAMIDAL