

MISE - Physical Basis of Chemistry
Seventh Set of Problems - Due No Later Than Sunday, March 25.

Due to the necessity of drawing Lewis structures to answer some of these question, you may submit the homework assignment by “snail-mail”, addressed to me:

Due by Sunday, March 25. This homework may be sent by snail mail to:

Carol Rulli
37 Old Colony Lane
Marlton, NJ 08053

You may scan your document and post it to the drop box or if you'd like you can use a molecular drawing program and submit the document to the drop box by the due date.

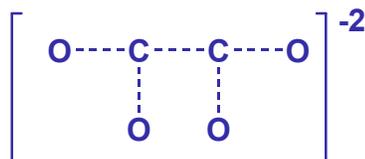
Note: When submitting to digital Drop Box label your files with **your name first** and then the label - **HmwkSeven**. **Please put you name in the 'Header' along with the already-inserted page #.**

1. For each of the following molecules/ions - unless otherwise indicated - the central atom is the first atom in the chemical formula. [Thus, all *other* atoms in the molecule are attached *only* to the central atom and not to each other in any way.] Consider the following:

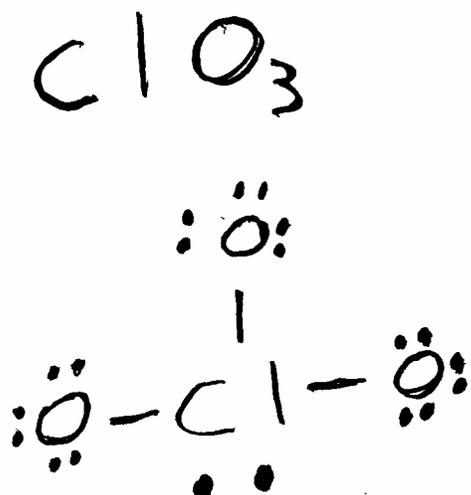
chlorate ion: ClO_3 ; sulfur trioxide: SO_3 ; perchlorate ion: ClO_4 ;

dichloroacetylene (C_2Cl_2), arrangement: $\text{Cl}-\text{C}-\text{C}-\text{Cl}$; and the oxalate anion

($\text{C}_2\text{O}_4^{2-}$), arrangement:

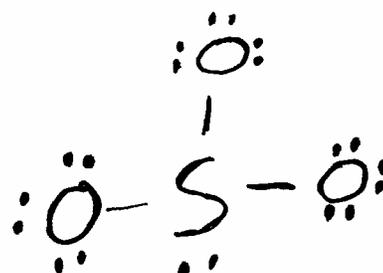


Draw the best Lewis octet structure each of the above molecules/ions - based upon formal charge considerations. For your best structure, please display all non-zero formal charges. [If more than one (resonance) structure contributes equally to the best structure, please show all equivalent resonance structures.]



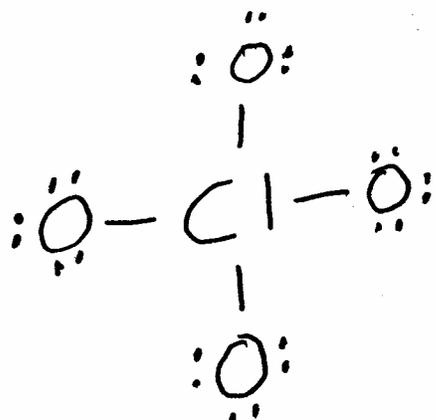
Trigonal
bent
non polar

Trigonal bent less than 120 degrees for ClO_3



Trigonal Bent
non polar

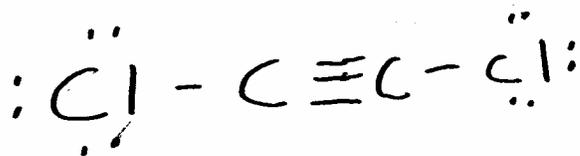
Trigonal bent less than 120 degrees for SO_3



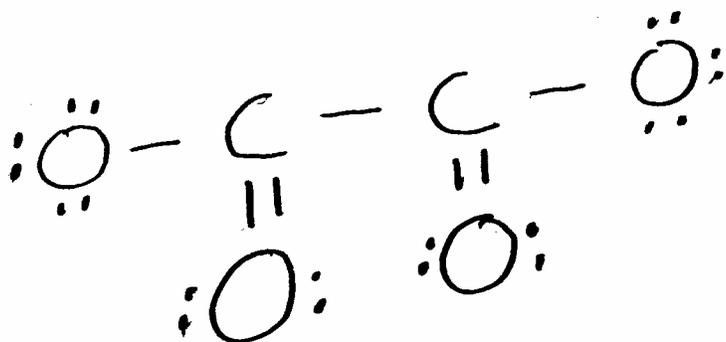
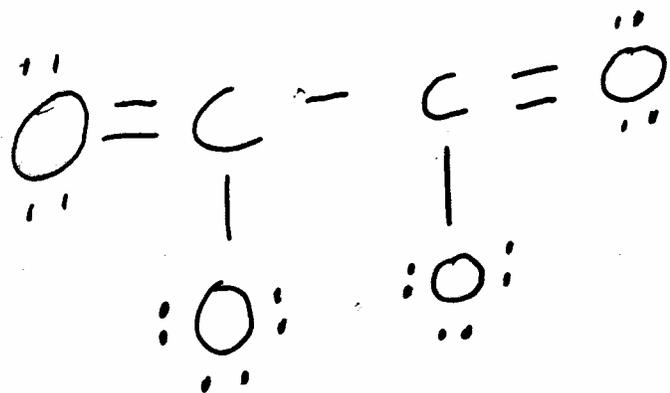
Tetrahedral

Trigonal pyramidal

non polar



Linear
non polar



Polar

2. For the chlorate ion, sulfur trioxide, and the perchlorate ion, predict the (ideal) geometry according to the VSEPR model and the steric number of the central atom. Write down the name of the ideal geometry (linear, trigonal planar, or tetrahedral) *and the ideal bond angle*. Then, determine how the bond angles alter (increase/decrease) due to the presence of lone pair electrons on the central atoms. [Recall that two lone pairs will

alter the ideal bond angle to a greater extent than one lone pair.]

3. Considering all of the molecules/ions in question 1: the chlorate ion, sulfur trioxide, the perchlorate ion, the oxalate ion, *and* dichloroacetylene, which are predicted to be polar and which are predicted to be non-polar? Explain your answers in terms of the VSEPR model and the “pulling” of any polar covalent bonds.

(Continued ---->)

4. Draw (best) Lewis structures and use the VSEPR model to answer/explain the following. [For each of the listed molecules below- the central atom is the first atom in the chemical formula. Thus, all *other* atoms in the molecule are attached *only* to the central atom and not to each other in any way.]

- (a) Silicon tetrachloride (**SiCl₄**) and silicon dioxide (**SiO₂**) are predicted to be non-polar whereas phosphorus trichloride (**PCl₃**) and silicon dichloride (**SiCl₂**) are predicted to be polar.

Silicon tetrachloride (**SiCl₄**) and silicon dioxide (**SiO₂**) are non-polar because the geometry of the molecules cancel out the difference in electro negativity. Phosphorus trichloride (**PCl₃**) and silicon dichloride (**SiCl₂**) are molecules where the are lone pairs of electrons that will not cancel out the effects of the imbalance of electro negativity between the atoms.

- (b) *Intermolecular Forces (IMF's) are attractive forces that arise between molecules due to charges polarizing within the molecule.* Thus, molecules that are predicted to be polar (using the VSEPR model) should have stronger IMF's than non-polar molecules. [Of course, for the polar molecules, the greater the polarity of the individual polar covalent bonds, the stronger the resultant IMF's.] A consequence of all of this is that properties that are affected by intermolecular forces - such as the liquid ----> gas boiling temperature (a.k.a. *boiling point*) - can be rationalized by the relative strengths of these IMF's. With all of the above in mind please answer the following. Be sure to *explain* your answers.

- (i) Which should have the higher boiling point (b.p.), **H₂S** or **H₂O**? Explain.

H₂O should have the higher boiling point. Sulfur having its valence shell on the 3rd energy level has a slightly less attraction from the nucleolus. The bonds of water should have a greater attraction due to the greater electro- negativity.

- (ii) Arrange the following in order of increased boiling point (b.p.). Carefully explain the reason for your ordering. **NF₃** , **CF₄** , & **PF₃** .

PF₃ should have the highest boiling point due to the biggest disparity in electro-negativity and paired electrons. **CF₄** , should have the lowest boiling point due to its relative low disparity in electro-negativity and having no lone pairs of electrons. **NF₃** , comes in between due to its lone pair of electrons and the closeness to the electro-negativity difference between **CF₄**.