Chemistry 123 **DUE MONDAY, March 3, 2003 @ 6:30 p.m.** **Winter Term 2003**
Assignment #5 **1 Page / 3 Problems SHOW YOUR WORK!** **Instructor: R. Rossi**

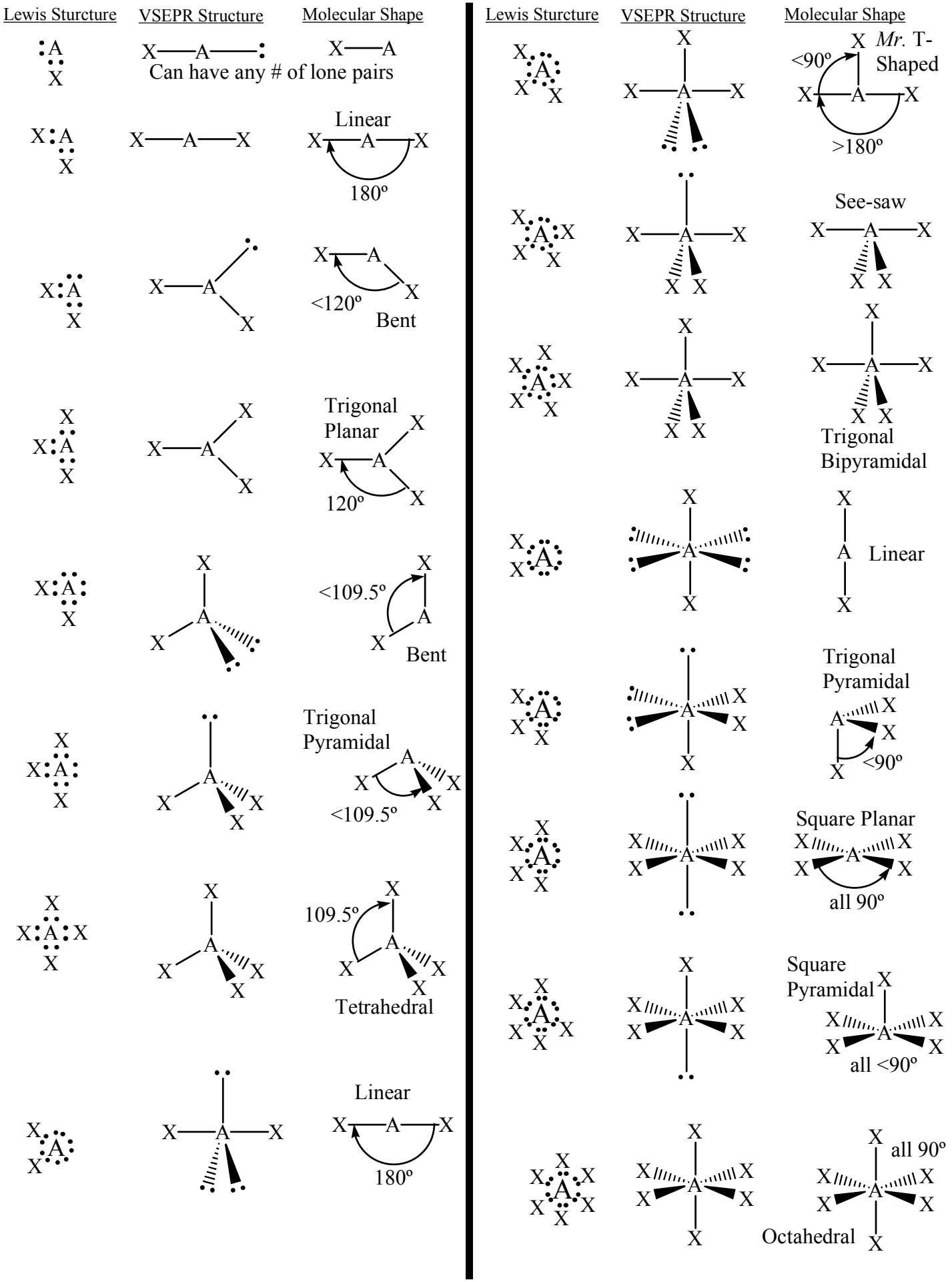
Your Name: _____

At what time and on what day was this handed in? _____

1. Given that the following ions exist, (in fact, they are common and important!) draw the best Lewis structure(s) for each. These follow the 8-electron "rule." Indicate formal charges, and if there are reasonable resonance forms, please show them. Use VSEPR to determine the steric number of the central atom in the ion (if it has one) and draw the ion's overall shape. (Remember that the sum of the formal charges in any system must add up to the net ionic charge! A 2+ ion *must* have a net formal charge of +2!)
   a. Cyanide ion, $[CN]^-$ (Not recommended for ingestion in the body; a very unpleasant way to go.)
   b. Cyanate ion, $[OCN]^-$ (Much less poisonous – an experimental sickle-cell anemia treatment) (This is connected in the order indicated above: O to C to N; carbon is in the middle.)
   c. Nitrate ion, $[NO_3]^-$ (Used in making dynamite, what Nobel got his $$$ for!) **(It contains no O–O bonds!)**
   d. Ammonium ion, $[NH_4]^+$ (The form of fixed nitrogen commonly used in nitrogenous agricultural fertilizers)

2. Draw the optimal Lewis structure(s) of each of the following molecules or ions, and indicate the molecule or ion's geometric shape as predicted by VSEPR. Assign the formal charges to all the atoms in each structure, indicating these charges right next to each atom. In developing Lewis structures for phosphorus and atoms beyond it in the periodic table, you should assume them to be capable of what is (oddly) called "expanded octet" behavior. These systems typically have steric numbers of five or six.
   a. **PF_6^-** The PF_6^- ion is octahedral and has a somewhat unfavorable formal charge distribution – but there is no way to do better.
   b. **$SOCl_2$** There are two reasonable structures for $SOCl_2$, one with no formal charge and one with a reasonable +1/-1 split. These two structures resonate.
   c. **BrF_5** BrF_5 has an octahedral arrangement of electron pairs and zero formal charges.
   d. **PO_4^{3-}** The phosphate ion is tetrahedral and has four resonance structures. The formal negative charges are all on the more electronegative atom(s).
   e. **SOF_4** SOF_4 has a trigonal bipyramidal VSEPR frame, and two reasonably good resonance structures.
   f. **ICl_4^-** The iodine tetrachloride ion has an octahedral arrangement of electron pairs and the formal charge is on the iodine.
   g. **$IO_2F_2^-$** Three resonance structures can be drawn for the $IO_2F_2^-$ ion, but two have a more reasonable formal charge distribution than the last. (Draw all three!)
   h. **I_3^-** The I_3^- ion is tricky. Is it linear or bent? Be careful! Remember that according to VSEPR mythology, lone pairs are "fat," and they like to have as much "elbow room" as possible. It turns out that things 90º away bother them, while things 120º away do not.
   i. **BrF_3** BrF_3 only makes sense drawn one way.

3. Acetic acid (**CH_3COOH**) is the molecule that gives vinegar its zing, both in terms of smell and taste. The smell of vinegar comes about because the neutral acetic acid molecule is volatile and readily enters into the gas phase. The sour taste of vinegar is common to all acids, and is caused by the presence of free H^+ ions (they actually bind to water to form H_3O^+ ions) in water.
   a. Draw a Lewis structure for acetic acid, the neutral molecule. The atoms are aligned as indicated in the "extended formula" of acetic acid, **CH_3COOH**.
   b. Draw a three-dimensional representation of the acetic acid molecule, by applying VSEPR to each atomic center independently. Use bold wedges and dashed lines to indicate perspective.
   c. Draw the Lewis structure for the acetate ion, **CH_3COO^-**.


Lewis Sturcture
VSEPR Structure
Molecular Shape
Can have any # of lone pairs
Linear
180º
<120º
Bent
Trigonal Planar
120º
<109.5º
Bent
Trigonal Pyramidal
<109.5º
109.5º
Tetrahedral
Linear
180º
Lewis Sturcture
VSEPR Structure
Molecular Shape
Mr. T-Shaped
<90º
>180º
See-saw
Trigonal Bipyramidal
Linear
Trigonal Pyramidal
<90º
Square Planar
all 90º
Square Pyramidal
all <90º
all 90º
Octahedral