CHEM 100
Chemistry I
Problem Set IX
Chapter 10

Due: Wednesday, 6-December-2006. Please remember that this is to be your own work.

1) The nitrogen-nitrogen bond distance in N\(_2\) is 109 pm. On the basis of bond orders, would you expect the bond distance in N\(_2^+\) to be greater or less than that for N\(_2\)? Answer this same question for N\(_2^-\).

2) The ionization energy of O\(_2\) is smaller than the ionization energy of atomic O; the opposite is true for N\(_2\) and atomic N. Explain this behavior in terms of the molecular orbital diagrams for N\(_2\) and O\(_2\).

For these next two problems, you should review Valence Bond Theory in the book. (pp. 410-423) [Table 10.2 (p. 413) will be helpful too.]

3) Excess fluorine, F\(_2(g)\), reacts at 150\(^\circ\)C with bromine, Br\(_2(g)\), to give a compound BrF\(_n(g)\). If 423 mL Br\(_2(g)\) at 150\(^\circ\)C and 748 mm Hg produced 4.20 g BrF\(_n\), what value does \(n\) have? Describe the bonding in the molecule, using valence bond theory.

4) One resonance formula for benzene, C\(_6\)H\(_6\), is:

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      H
   H-C-C-C-C-H
  H  H   H   H
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What is the other resonance formula? What is the geometry about a carbon atom? What hybridization would be used in a valence bond theory description? The \(\Delta H^\circ_f\) for C\(_6\)H\(_6(g)\) is -83 kJ/mol; \(\Delta H^\circ_f\) for C\(_{(g)}\) is 715 kJ/mol. Obtain the resonance energy of benzene. [The resonance energy is defined as \(\Delta H^\circ_f(estimated) - \Delta H^\circ_f(actual)\)]

5) Refer back to the MO diagram I generated in class for the AH\(_2\) molecules. Now imagine you are a chemist who has been asked to predict the geometry of methylene, CH\(_2\). (Yes, it really does exist!) By first drawing a Lewis dot structure, then using your molecular orbital diagram, predict the preferred geometry if all the electrons are paired. Do the same for any structures you can envision in which any “lone pair” electrons are not paired but instead, spin parallel. Are these geometries different? Comment.