CH 222 Winter 2025:

Problem Set #2

Instructions

Step One (all sections):

- **Learn the material** for Problem Set #2 by **reading Chapter 8** of the textbook and/or by watching the videos found on our website (https://mhchem.org/222)
- **Try the problems** for Problem Set #2 found on the next pages on your own first. **Write out the answers (and show your work) by hand (on a tablet or paper)**; do not type your answers (and work) to avoid a point penalty. If you write the answers on the problem set itself, you will receive fewer points. Include your name on your problem set!

Step Two:

Section H1: We will go over Problem Set #2 during recitation. ***Self correct all problems*** of your problem set before turning it in at the end of recitation.

- *Section H1:* due **Wednesday, January 22 at 1:10 PM**

Section 01 ***and*** *Section W1:* **Watch the recitation video** for Problem Set #2 here:
http://mhchem.org/y/u.htm

Self correct *all* of the problems while viewing the video. Mark correct problems with a star (or other similar mark), and correct all incorrect problems (show the correct answer and the steps required to achieve it.)

- *Section W1:* **S**ubmit Problem Set #2 via **email (mike.russell@mhcc.edu) as a single PDF file** (use CamScanner (https://camscanner.com), CombinePDF (https://combinepdf.com), etc.) **by 11:59 PM Wednesday, January 22.**
- *Section 01:* Due to MLK day, submit Problem Set #2 as a hard copy (nothing electronic) on **9 AM, Wednesday January 22 in AC 1303** (lecture.)

If you have any questions regarding this assignment, please email (mike.russell@mhcc.edu) the instructor! Good luck on this assignment!

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** Complete problem set on separate pieces of paper showing all work, circling final answers, etc.*
** Self correct your work before turning it in to the instructor.*

Covering: **Chapter Eight** *and* **Chapter Guide Two**
Important Tables and/or Constants: "**MO Diagram for B_2, C_2, and N_2" / "MO Diagram for O_2, F_2, and Ne_2"** *(Handouts,* http://mhchem.org/MO*),* "**Geometry and Polarity Guide**" *(Handout,* https://mhchem.org/geopo*)*

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1. Draw the Lewis structure of NF_3. What are its electron pair and molecular geometries? What is the hybridization of the nitrogen atom? What orbitals on N and F overlap to form bonds between these elements?
2. Specify the electron pair and molecular geometry for each of the following. Describe the hybrid orbital set used by the central atom in each molecule or ion.
    a. CSe_2
    b. SO_2
    c. CH_2O
    d. NH_4^+
3. Draw the Lewis structure and then specify the electron pair and molecular geometries for each of the following molecules or ions. Identify the hybridization of the central atom.
    a. $XeOF_4$
    b. OSF_4
    c. BrF_5
    d. The central atom in Br_3^{-1}
4. The compound C_4H_8 has six isomers. Draw them. (*Note:* 4 of them have a double bond.)
5. Give the electron configurations for the Li_2, Li_2^{+1} and Li_2^{-1} in molecular orbital terms. Compare the Li-Li bond order in the three species; which has the shortest bond length?
6. Oxygen, O_2, can acquire one or two electrons to give O_2^{-1} (superoxide ion) or O_2^{2-} (peroxide ion.) Write the molecular orbital configuration for O_2, O_2^{-1} and O_2^{2-}. Remember to use the molecular orbital diagram for O_2, F_2 and Ne_2 when constructing the diagrams. For each species, determine the
    a. Magnetic character
    b. Net number of σ and π bonds
    c. Bond order
    d. Relative oxygen-oxygen bond length
7. The nitrosyl ion, NO^+, has an interesting chemistry. Use the "O_2, F_2 and Ne_2" molecular orbital diagram for this problem.
    a. Is NO^+ diamagnetic or paramagnetic? If paramagnetic, how many unpaired electrons does it have?
    b. What is the highest energy occupied molecular orbital (HOMO) in the molecule? What is the lowest unoccupied molecular orbital (LUMO) in the molecule?
    c. What is the nitrogen-oxygen bond order?
    d. Is the N-O bond in NO^+ stronger or weaker than the bond in NO? Explain.

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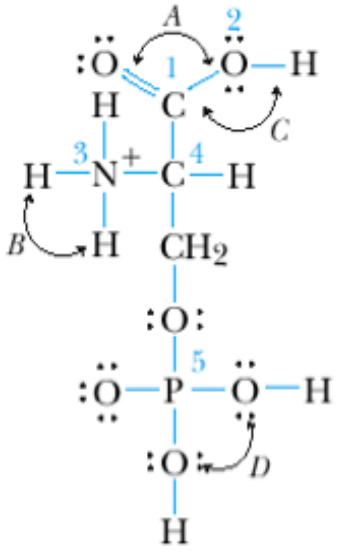
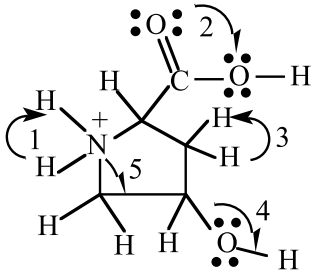
8. Nitrogen, N_2, can ionize to form N_2^{+} or add an electron to form N_2^{-1}. Using molecular orbital theory, compare these three species with regard to:
    a. Their magnetic character
    b. Net number of π bonds
    c. Bond order
    d. Bond length
    e. Bond strength
9. Phosphoserine is a less common amino acid with the structure shown to the right.
    a. Describe the hybridization of atoms 1 through 5.
    b. What are the approximate values of the bond angles *A*, *B*, *C* and *D*?
10. Sketch the Lewis structures of ClF_2^{+} and ClF_2^{-1}. What are the electron pair and molecular geometries of each ion? Do both have the same F-Cl-F- angle? What hybrid set is used in each ion?
11. Compare the structure and bonding in CO_2 and CO_3^{2-} with regard to:
    a. The O-C-O bond angles
    b. The CO bond order
    c. The C atom hybridization.
    d. Does the molecule CO have a stronger bond than CO_2 and/or CO_3^{2-}? Explain.
12. Hydroxyproline is an unusual amino acid with the structure shown to the right.
    a. What are the approximate values for the bond angles for *1*, *2*, *3*, *4* and *5*?
    b. Describe the hybridization around the central atom for *1*, *2*, *3*, *4* and *5*.
13. Iodine and oxygen form a complex series of ions, among them IO_4^{-1} and IO_5^{-3}. Draw the Lewis structures for these ions and specify their electron pair and molecular geometries. What is the hybridization of the I atom in these ions?
14. Which of the following molecules or ions should be paramagnetic? What is the highest occupied molecular orbital (HOMO) in each one? Note that if an O, F or Ne is present in the molecule, you should use the molecular orbital diagram for O_2, F_2 and Ne_2 to construct the molecule.
    a. NO
    b. OF^{-1}
    c. O_2^{2-}
    d. Ne_2^{+1}
    e. CN



Phosphoserine



Hydroxyproline

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