CH 221 Fall 2025:
Problem Set #5
Instructions

Step One:

• **Learn the material** for Problem Set #5 by **reading Chapter 5** of the textbook and/or by watching the videos found on the website (https://mhchem.org/221video)

• **Try the problems** for Problem Set #5 found on the next pages on your own first. Write your answers in the space provided or write your answers on separate paper (your choice.) Include your name on your problem set!

Step Two:

Watch the recitation video for Problem Set #5:

http://mhchem.org/1/5

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.)

Step Three:

Turn the Problem Set in at the beginning of recitation to the instructor on **Monday, November 3 (section L1), Tuesday, November 4 (section L2) Wednesday, November 5 (section L3)** *or* **Friday, November 7 (section L4)** The graded problem set will be returned to you the following week during recitation.

Do *not* include this page to avoid a point penalty; your front page should be page II-5-3.

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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CH 221 Problem Set #5

Name:

Complete the problem set on your own first using these sheets for your work or separate paper (your choice.) **Self correct your work *(all problems!)*** using the recitation video for this problem set, found here: **http://mhchem.org/1/5**

***** *Covering:* **Chapter Five** *and* **Chapter Guide Five**

* *Important Tables and/or Constants:* periodic table (http://mhchem.org/pertab)**,** "**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. *Draw Lewis structures!*
   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

    d. The central atom in Br_3^-

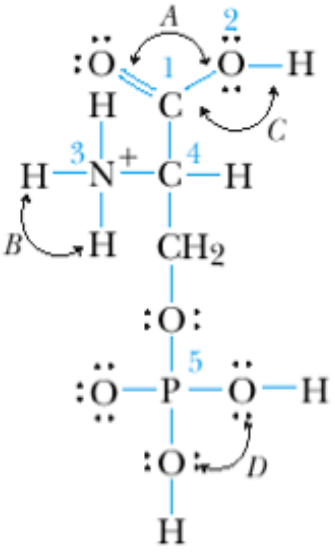
4. Give the electron configurations for the Li_2, Li_2^{+1} and Li_2^{-1} in molecular orbital terms. Compare the Li-Li bond order in the three species; which has the shortest bond length?

5. 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

6. 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.

7. 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

8. 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*?



Phosphoserine

9. 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?

10. 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.

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