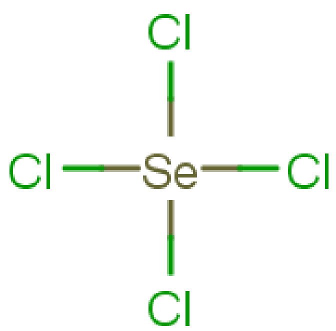
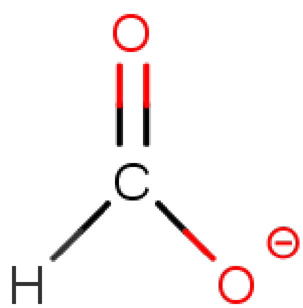
Chem 105 Exam 2 Name_______________________

This exam is schedule for 75 minutes and I anticipate it to take the full time allotted. You are free to leave if you finish. In multiple part problems, points awarded will not be penalized for incorrect answer on previous parts, so simply **move on if you get stuck on one part**. If you need to, make up an answer for the previous part. Always neatly show work for partial credit.

When you draw Lewis structures ALWAYS include lone pairs and redraw them to show the correct molecular geometry! A '*connect the dots*' structure is not complete and will not receive full credit. **Show all formal charge.**

1. **Incomplete** Lewis structure for three molecules are shown below. All charges are clearly labeled on the correct atom. Complete each of the following:
    a. Add lone pairs to complete the structures.
    b. If resonance forms exist, draw at least one.
    c. Determine the hybridization of **all** atoms.
    d. Determine all bond angles (if all bond angles are the same, you only need to label one).
    e. Redraw each molecule so that the molecular geometry is clear.





2. Each of the molecules below has only **one central atom**. Draw the Lewis structure for each molecule. Make sure to follow the guidelines on the first page. **Label all formal charge.**

On each molecule:

a. Determine the **molecular** geometry around the **central** atom.
b. For neutral molecules, indicate whether they are polar or nonpolar (circle the correct answer).
c. Indicate how many resonance forms exist.

CF_2Br_2 (polar or nonpolar)
Number of resonance forms ______

Mol. Geometry _________________

NO_3^{-1}
Number of resonance forms ______

Mol. Geometry _________________

SO_3^{2-}
Number of resonance forms ______

Mol. Geometry _________________

SO_3 (polar or nonpolar)
Number of resonance forms ______

Mol. Geometry _________________

SO_2 (polar or nonpolar)
Number of resonance forms ______

Mol. Geometry _________________

SO_2^{2-}
Number of resonance forms ______

Mol. Geometry _________________

3. True or false:
    a. All atoms with sp^3 hybridization have tetrahedral **electron** geometry.

    True **False**

    b. All atoms with sp^3 hybridization have tetrahedral **molecular** geometry.

    True **False**

    c. Some sp^3d^2 hybridized atoms can have linear molecular geometry.

    True **False**

    d. An atom can have s^2p^2 hybridization.

    True **False**

    e. A nitrogen atom can have sp^3d hybridization.

    True **False**

4. Clearly explain why some atoms are able to break the octet rule.

5. Name each of the following compounds:

$FeCl_3$ $Mg(BrO_4)_2$ HF

6. Determine the correct molecular formula for each of the following compounds:

Ammonium nitride copper (I) nitrite disulfur heptachloride

7. Is Pd^{-2} (Z=46) a common ion? Clearly justify your answer.

8. Tales from the past: Order the following by increasing radius (smallest → largest):

O^{2-}, Ne, Mg^{2+}, Cl^{-}

9. What are two stable indium ions (Z = 49)? Using electron configurations, justify why they are stable.

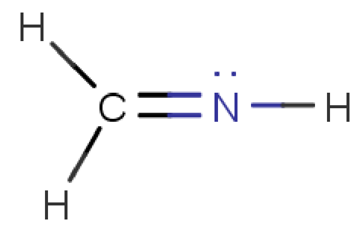
10. Consider the following molecules. Rank them by order of increasing boiling temperatures. Justify your answer for credit – no points will be given without an explanation.

NH_3 NCl_3 PCl_3 PH_3

11. What is the difference between a sigma bond and a pi bond?

12. Answer **one** problem from this page:

a. Using hybridization theory, sketch an energy diagram for the bonds between **carbon and nitrogen** in CH_2NH. In your diagram, identify what each electron is doing – you may reference the Lewis structure shown below.



b. Using molecular orbital theory, determine which of these molecules would be attracted to a magnet. To receive any credit, you must show how you arrived at your answer.

CN^{-1} NO^{-1} CO^{-1}

MO order: σ_{2s}, σ_{2s}*, σ_{2p}, π_{2p}, π_{2p}*, σ_{2p}*

13. Answer **ONE** of the following. **You must fully explain your answer to receive credit**. Answer more for bonus credit.

a. Consider N_2, O_2, and CO. N-N and O-O bonds are both non-polar; C-O bonds are polar. Based on this, we would predict that CO would have a significantly higher boiling temperature than the other two; however, the trend is $N_2 < CO < O_2$. Explain this trend (Hint, it has nothing to do with molecule size).

b. PCl_3F_2 can be polar or nonpolar depending on the arrangement of atoms. Draw this molecule in two ways that clearly explains the previous statement. Make sure to show bond polarity to support your answer.

c. Which of these molecules has the longest S-O bond? SO_3 SO_3^{2-} SO_2^{-2} SO_2

d. Use MO theory to predict the number of sigma and pi bonds in C_2. Based on your finding, do you think that this molecule can form? σ_{2s}, σ_{2s}^*, π_{2p}, σ_{2p}, π_{2p}^*, σ_{2p}^*

e. Draw the Lewis structure of the molecule described:

This monovalent anion consists of a neutral central atom from the 5th shell with seesaw geometry. It has covalent bonds to one type of atom from the 3rd shell and one type of atom from the 4th shell. None of the atoms carry a permanent formal charge of -1. One pi bond exists in this molecule and two resonance forms can be drawn.

Periodic Table of the Elements

Element Name → Mercury
Atomic Number → 80
Symbol → Hg
Average Mass → 200.59
Electronegativity → 1.9

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Hydrogen 1 H 1.01 2.1																		Helium 2 He 4.00 ---
Lithium 3 Li 6.94 1.0	Beryllium 4 Be 9.01 1.5												Boron 5 B 10.81 2.0	Carbon 6 C 12.01 2.5	Nitrogen 7 N 14.01 3.0	Oxygen 8 O 16.00 3.5	Fluorine 9 F 19.00 4.0	Neon 10 Ne 20.18 ---
Sodium 11 Na 22.99 0.9	Magnesium 12 Mg 24.31 1.2												Aluminum 13 Al 26.98 1.5	Silicon 14 Si 28.09 1.8	Phosphorus 15 P 30.97 2.1	Sulfur 16 S 32.07 2.5	Chlorine 17 Cl 35.45 3.0	Argon 18 Ar 39.95 ---
Potassium 19 K 39.10 0.8	Calcium 20 Ca 40.08 1.0		Scandium 21 Sc 44.96 1.3	Titanium 22 Ti 47.88 1.5	Vanadium 23 V 50.94 1.6	Chromium 24 Cr 52.00 1.6	Manganese 25 Mn 54.94 1.5	Iron 26 Fe 55.85 1.8	Cobalt 27 Co 58.93 1.8	Nickel 28 Ni 58.69 1.8	Copper 29 Cu 63.55 1.9	Zinc 30 Zn 65.39 1.6	Gallium 31 Ga 69.72 1.6	Germanium 32 Ge 72.61 1.8	Arsenic 33 As 74.92 2.0	Selenium 34 Se 78.96 2.4	Bromine 35 Br 79.90 2.8	Krypton 36 Kr 83.80 3.0
Rubidium 37 Rb 85.47 0.8	Strontium 38 Sr 87.62 1.0		Yttrium 39 Y 88.91 1.2	Zirconium 40 Zr 91.22 1.4	Niobium 41 Nb 92.91 1.6	Molybdenum 42 Mo 95.94 1.8	Technetium 43 Tc (98) 1.9	Ruthenium 44 Ru 101.07 2.2	Rhodium 45 Rh 102.91 2.2	Palladium 46 Pd 106.42 2.2	Silver 47 Ag 107.87 1.9	Cadmium 48 Cd 112.41 1.7	Indium 49 In 114.82 1.7	Tin 50 Sn 118.71 1.8	Antimony 51 Sb 121.76 1.9	Tellurium 52 Te 127.60 2.1	Iodine 53 I 126.90 2.5	Xenon 54 Xe 131.29 2.6
Cesium 55 Cs 132.91 0.7	Barium 56 Ba 137.33 0.9	57-70 *	Lutetium 71 Lu 174.97 1.1	Hafnium 72 Hf 178.49 1.3	Tantalum 73 Ta 180.95 1.5	Tungsten 74 W 183.84 1.7	Rhenium 75 Re 186.21 1.9	Osmium 76 Os 190.23 2.2	Iridium 77 Ir 192.22 2.2	Platinum 78 Pt 195.08 2.2	Gold 79 Au 196.97 2.4	Mercury 80 Hg 200.59 1.9	Thallium 81 Tl 204.38 1.8	Lead 82 Pb 207.20 1.8	Bismuth 83 Bi 208.98 1.9	Polonium 84 Po (209) 2.0	Astatine 85 At (210) 2.2	Radon 86 Rn (222) 2.4
Francium 87 Fr (223) 0.7	Radium 88 Ra (226) 0.9	89-102 **	Lawrencium 103 Lr (262) ---	Rutherfordium 104 Rf (261) ---	Dubnium 105 Db (262) ---	Seaborgium 106 Sg (266) ---	Bohrium 107 Bh (264) ---	Hassium 108 Hs (269) ---	Meitnerium 109 Mt (268) ---	Darmstadtium 110 Ds (271) ---	Roegentium 111 Rg (272) ---	Copernicium 112 Cn (277) ---	Ununtrium 113 Uut (284) ---	Flerovium 114 Fl (289) ---	Ununpentium 115 Uup (288) ---	Livermorium 116 Lv (293) ---	Ununseptium 117 Uus (294) ---	Ununoctium 118 Uuo (294) ---

*lanthanides	Lanthanum 57 La 138.91 1.1	Cerium 58 Ce 140.12 1.1	Praseodymium 59 Pr 140.91 1.1	Neodymium 60 Nd 144.24 1.1	Promethium 61 Pm (145) 1.1	Samarium 62 Sm 150.36 1.2	Europium 63 Eu 151.97 1.1	Gadolinium 64 Gd 157.25 1.2	Terbium 65 Tb 158.93 1.1	Dysprosium 66 Dy 162.50 1.2	Holmium 67 Ho 164.93 1.2	Erbium 68 Er 167.26 1.2	Thulium 69 Tm 168.93 1.3	Ytterbium 70 Yb 173.04 1.1
**actinides	Actinium 89 Ac (227) 1.1	Thorium 90 Th 232.04 1.3	Protactinium 91 Pa 231.04 1.5	Uranium 92 U 238.03 1.4	Neptunium 93 Np (237) 1.4	Plutonium 94 Pu (244) 1.3	Americium 95 Am (243) 1.3	Curium 96 Cm (247) 1.3	Berkelium 97 Bk (247) 1.3	Californium 98 Cf (251) 1.3	Einsteinium 99 Es (252) 1.3	Fermium 100 Fm (257) 1.3	Mendelevium 101 Md (258) 1.3	Nobelium 102 No (259) 1.3