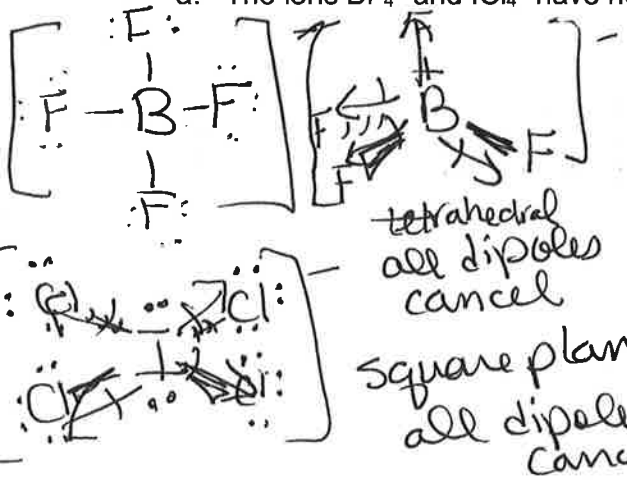
Exam 2
Friday, October 13
100 pts

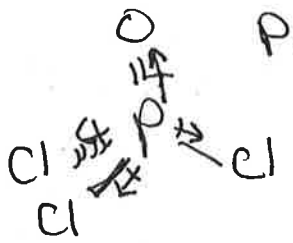
1. (24 pt) Explain each of the following true statements, **supporting your answers with diagrams and other supporting information as necessary**! Note that it is better to say why your model does not fit the rather than just making up invalid stuff in order to make it agree! (8 pt each)

a. The ions BF_4^- and ICl_4^- have no net dipole moments but the molecule $POCl_3$ is polar.



tetrahedral
all dipoles cancel

square planar
all dipoles cancel

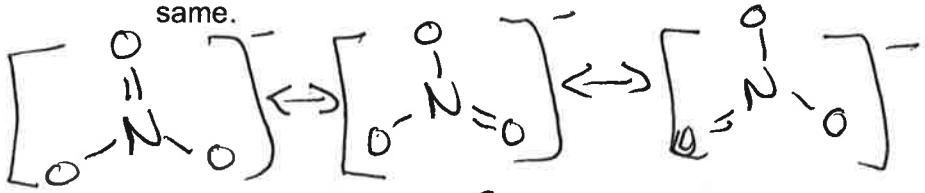


PO dipole arrow is larger b/c

b. The size of Cd^{2+} is smaller than that of Rh^{2+} but it is also smaller than Sn^{2+}.

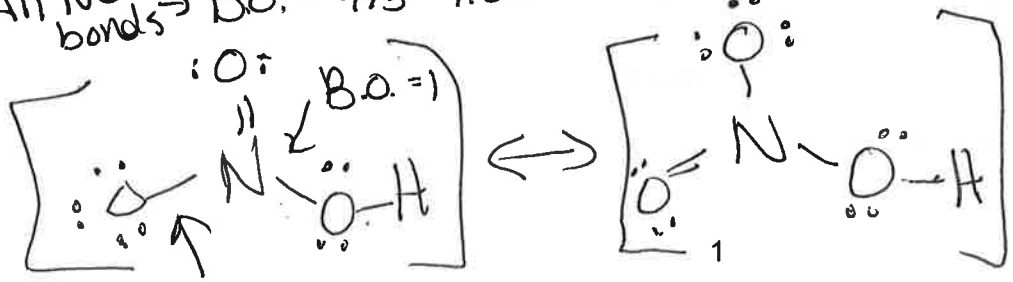
see problem on In Class 8!

c. There are two different N-O bond lengths in HNO_3 but the bond lengths in NO_3^- are all the same.



All NO bonds ⇒ B.O. = 4/3 = 1.33

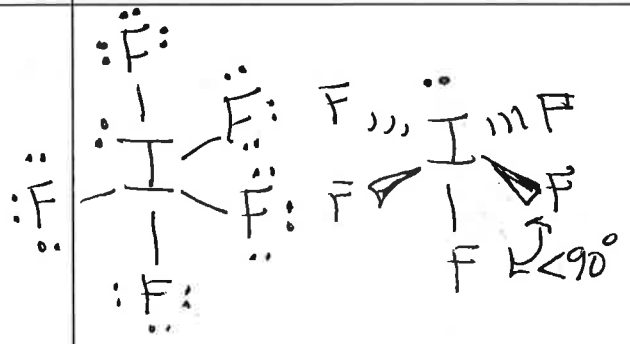
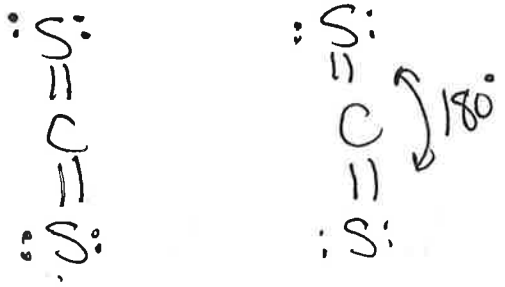
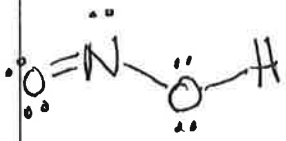
3 equivalent resonance structures all bonds are same



B.O. = 3/2

2 equiv res. structures but O w/ H has bond order of 1, other N-O bond lengths have bond order of 1.5.

2. (24 pts) Draw the **best** inequivalent Lewis dot structures (with equivalent resonance structures if appropriate) for the following molecules and ions. Predict the geometry, draw it in 3-D, label the bond angles. (8 pts each)

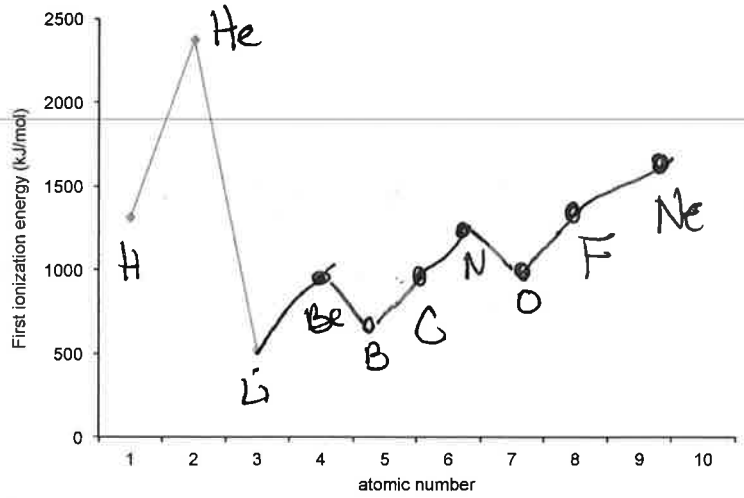
Formula	Lewis dot structure(s)	Draw geometry and indicate bond angles	Molecular geometry at **each** central atom(s)	Hybridiz. at **each** central atoms	Polar or non polar
IF_5			square pyramidal	sp^3d^2	polar
CS_2			linear	sp	non polar
HNO_2			bent N bent O	sp^2 sp^3	polar

3. a. Provide the chemical equation that represents the process for which electron affinity of the element P is calculated. (4 pt)

$$P^-(g) \longrightarrow P(g) + e^- \quad \Delta E = EA$$

b. (4 pt) As you go down the PT, electron affinity decreases because the e^- are further from the nucleus (higher q.p.l.) (one brief phrase!)

4. (9 pt) The graph below shows the values of first ionization energy for the first three elements (H, He, and Li).



a. Add *estimates* to the graph for the first ionization energies of the elements that complete the second row of the periodic table. (4 pt)

b. Explain the reason(s) for the trend(s) in ionization energies demonstrated by your graph (including any exceptions to the overall trends!). (5 pt)

Increases as you go across b/c increase in Z_{eff}
B<Be b/c 2p is easier to remove than 2s O<N b/c easier to remove e^- w/ e^--e^- repulsion 1 1 1 1 remove this

5. (18 pt, 3 pt each) Answer each of the following questions:

Ar a. The symbol for the element in period 3 with the highest Z_{eff}

5 b. The number of electron domains for SeF_4

O c. The smallest element in group VIA

+3, +5 d. The common charges for the element Bi

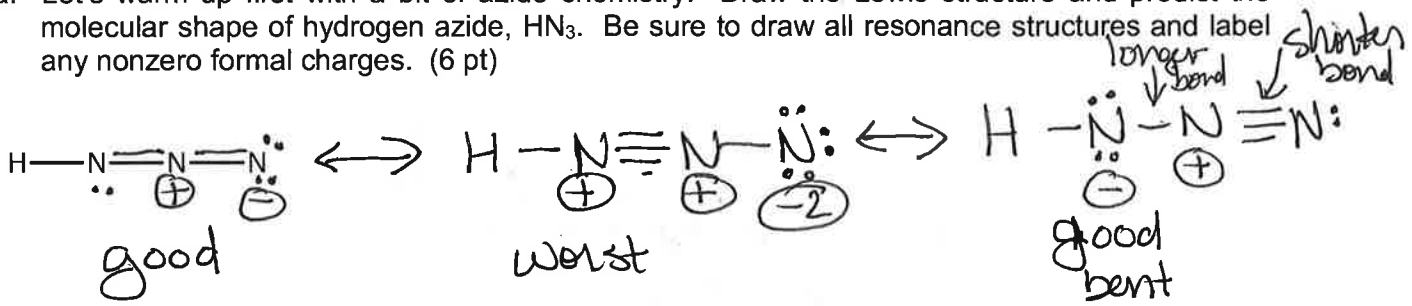
linear e. The molecular geometry for a central atom with three lone pairs and two bonded atoms

negative f. The sign of the energy change when you form a bond

6. (21 pt) An article in the journal *Inorganic Chemistry*[1] caught my eye, reporting the crystal structure of the "extremely explosive" carbonyl diazide, $OC(N_3)_2$. You can use Lewis dot structures and VSEPR to predict its structure.

   a. Let's warm up first with a bit of azide chemistry. Draw the Lewis structure and predict the molecular shape of hydrogen azide, HN_3. Be sure to draw all resonance structures and label any nonzero formal charges. (6 pt)

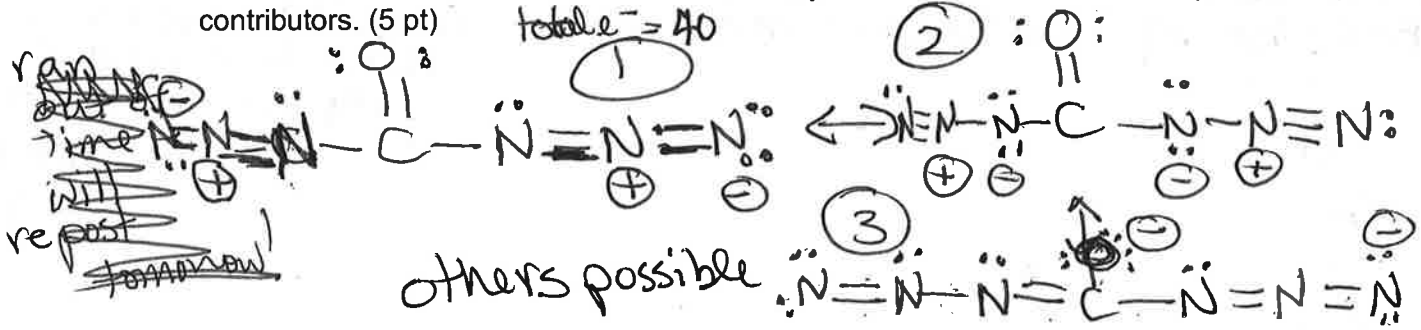
15 −1 −16 −6 10



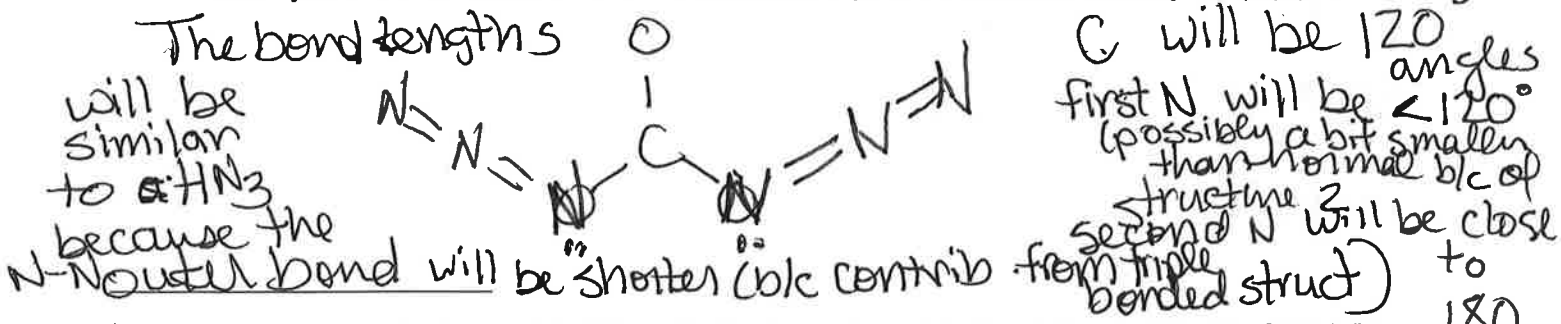
   b. The H–N–N bond angle in HN_3 is 112°. Does this match what you would predict from your structures in part a? There are 2 unequal N–N bond lengths in HN_3, 113 pm and 124 pm. On a picture of the molecular structure, indicate which bond is which and explain your assignment. As a point of reference, the triple bond length in N_2 is 109.8 pm. (6 pt)

actual bond is longer than a triple bond (but pretty close)
actual angle is < bent 120° and > bent 109.5°
These make sense given the 2 structures above that contribute to the overall structure!

   c. Now draw all important resonance structures for carbonyl diazide (the skeleton structure is drawn on the board!), $OC(N_3)_2$, labeling all atoms with nonzero formal charges. There are at least 6 resonance structures for this molecule; you should be able to come up with 3 important contributors. (5 pt)



   d. Based on the structures you drew above, draw a picture of the molecular structure that you would predict for carbonyl diazide **including your predictions for approximate bond angles.** How would you expect the different N–N bond lengths to compare in this molecule? Note: you can assume that the entire molecule is planar because it actually is! (4 pt)



[1] X. Zeng, M. Gerken, H. Beckers, and H. Willner, "Synthesis and Characterization of Carbonyl Diazide, $OC(N_3)_2$," *Inorg. Chem.* **2010**, *49*, 9694-9699.