

1. Explain how trimethylamine,  $N(CH_3)_3$ , can act as a (a. 8 pts) Brønsted-Lowry base and a (b. 8 pts.) Lewis base. 1. \_\_\_\_\_

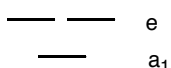
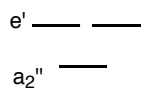
2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

5. \_\_\_\_\_

2. MO diagrams for  $BH_3$  and  $NH_3$  are drawn below.

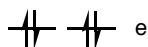
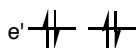


a. (4 pts.) In the reaction of  $BH_3$  and  $NH_3$  to form  $H_3BNH_3$ , which molecule acts as the Lewis base? 6. \_\_\_\_\_

7. \_\_\_\_\_



b. (4 pts.) In the reaction of  $BH_3$  with  $NH_3$  to form  $H_3BNH_3$ , which molecule acts as the Lewis acid? 8. \_\_\_\_\_



c. (8 pts.) Circle and label (with names) the MO's that participate in the formation of the acid-base adduct.



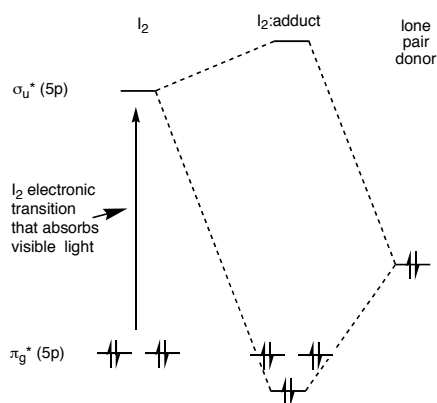
d. (6 pts.) Draw the new MO's that form when the adduct forms. Ignore all MO's not directly involved in adduct formation.



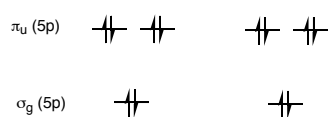
3. a. (8 pts.) Rank the following metal ions in order of increasing acidity.  $Zn^{2+}$ ,  $K^+$ , and  $Fe^{3+}$ .

b. (8 pts.) Draw a reaction that demonstrates how one of the ions can generate protons in aqueous solution.

4. Iodine absorbs light because an electron can be promoted from a  $\pi_g^*$  orbital to the  $\sigma_u^*$  orbital.

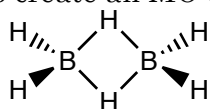


a. (6 pts.) Explain/describe the formation of the new molecular orbitals on the  $I_2$ :adduct.

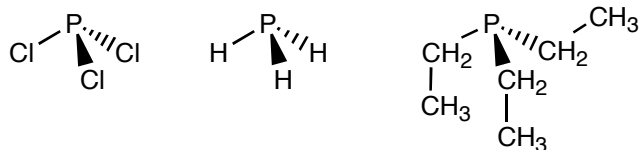


b. (6 pts.) Explain why the color of the light that is absorbed changes when the  $I_2$  acceptor-donor complex forms.

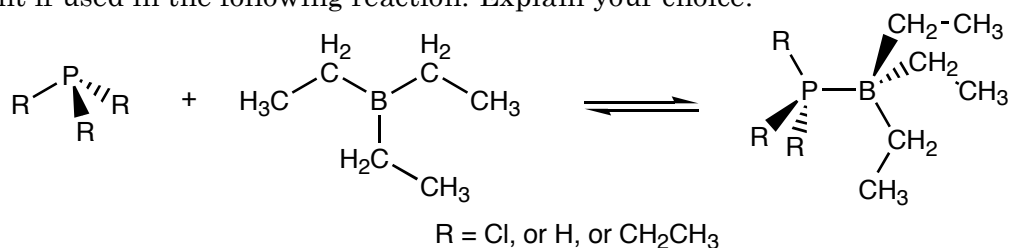
5. (10 pts) Describe the bonding in  $B_2H_6$ ; that is, describe whether the lines in the following structure indicate classical two-center two-electron bonds, and if they don't describe what the lines might mean. It is not necessary to create an MO diagram.



6. a. (8 pts.) Ignoring any solvent effects which of the following molecules would be the best at attracting protons. Explain your choice.



b. (8 pts.) Which of the above phosphines would produce a reaction with the largest equilibrium constant if used in the following reaction. Explain your choice.



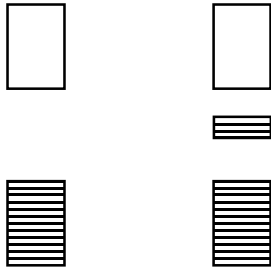
7. In crystals of lithium iodide it is said that the lithium occupies the octahedral holes of a face-centered cubic crystal of iodide ions.

a. (8 pts.) Describe the environment around each lithium ion; that is, describe how many iodide ions surround each lithium ion, and draw a sketch of one lithium ion and the iodide ions in the lithium ion's coordination sphere.

b. (8 pts.) Draw a sketch of one face of the unit cell for a lithium iodide crystals.

8. Two energy level diagrams are drawn below. One is a diagram for a semiconductor, the other is a diagram for a doped semiconductor. The empty rectangle represents an empty band, the rectangles with lines indicate bands filled with electrons.

a. (6 pts.) Label the valence and conduction bands in the undoped material.



b. (6 pts.) Is the doped semiconductor an n-type or a p-type semiconductor. Explain your response.

c. (6 pts) If the undoped material is silicon, would the semiconductor type be consistent with a gallium or arsenic dopant.

d. (8 pts.) Briefly describe two ways that this semiconductor can be made to conduct.