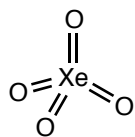1. (10 pts.) Xenon tetroxide is a tetrahedral compound and is a member of the T_d point group. The reducible representation for the stretching of the Xe=O bonds appears at the bottom of the T_d character table included below.

1. _____

2. _____

T_d	E	8 C_3	3 C_2	6 S_4	6 σ_d		
A_1	1	1	1	1	1		$x^2 + y^2 + z^2$
A_2	1	1	1	-1	-1		
E	2	-1	2	0	0		$2z^2 - x^2 - y^2,\ x^2 - y^2$
T_1	3	0	-1	1	-1	(R_x, R_y, R_z)	
T_2	3	0	-1	-1	1	(x, y, z)	(xy, xz, yz)
Γ	4	1	0	0	2		

3. _____

a. Determine the irreducible representations for the stretching of the Xe=O bonds.

4. _____

5. _____

6. _____

7. _____

b. How many IR peaks should be seen for the X=O stretching vibrations?

8. _____

9. _____

2. (10 pts.) Determine the irreducible representation for the reducible representation that appears in the last row of the C_{3v} character table below.

10. _____

C_{3v}	E	2 C_3	3 σ_v	
A_1	1	1	1	z
A_2	1	1	-1	R_z
E	2	-1	0	$(x, y), (R_x, R_y)$
Γ	7	1	-1	

11. _____

12. _____

13. _____

$$\begin{pmatrix} \text{number of irreducible} \\ \text{representations of a given} \\ \text{type needed} \end{pmatrix} = \frac{1}{\text{order}} \Sigma_{\text{classes}} \begin{pmatrix} \text{\# operations} \\ \text{in class} \end{pmatrix} \begin{pmatrix} \chi \text{ of the irreducible} \\ \text{representation} \end{pmatrix} \begin{pmatrix} \chi \text{ of the reducible} \\ \text{representation} \end{pmatrix}$$

3. (10 pts.) Below are cartoon representations of an s orbital on one atom and a p orbital on a second atom. Determine which pair of orbitals would interact to form molecular orbitals and briefly explain your response.

A

B
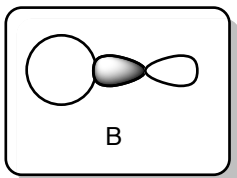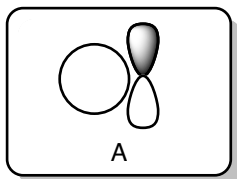
4. (12 pts.) Label the following MO's as bonding or anti-bonding and as σ, π, or δ symmetry. The two atoms are on the z axis equidistant from the origin.
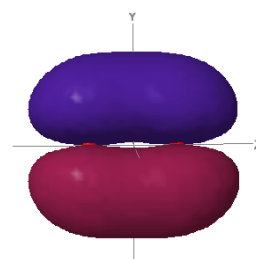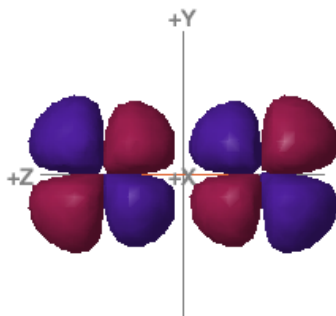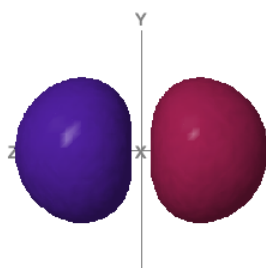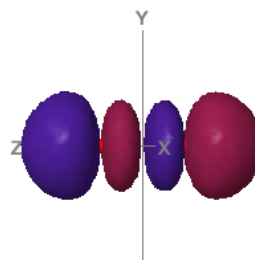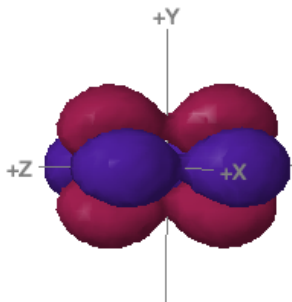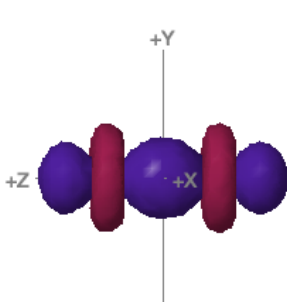

5. (10 pts.) a. The abbreviations HOMO and LUMO are short for what?

b. If a molecule is going to react as an electrophile, which orbital will likely be used, the HOMO or the LUMO.

6. (10 pts.) In NH_3 the three 1s orbitals on the H atoms form three symmetry adapted peripheral atom orbitals (SALCs). NH_3 is in the C_{3v} point group. Determine the symmetries of the three SALCs.

| C_{3v}	E	2 C_3	3 σ_v	
A_1	1	1	1	z
A_2	1	1	-1	R_z
E	2	-1	0	(x, y), (R_x, R_y)
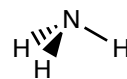
7. (2 pts. ea.) An incomplete MO for HF is draw to the right.

   a. Populate the atomic and molecular orbitals with the appropriate number of electrons.

   b. Label the orbital(s) that would be bonding.

   c. Label the orbital(s) that would be nonbonding.

   d. Label the orbital(s) that would be antibonding.

   e. the LUMO is primarily centered on the H or F atom?
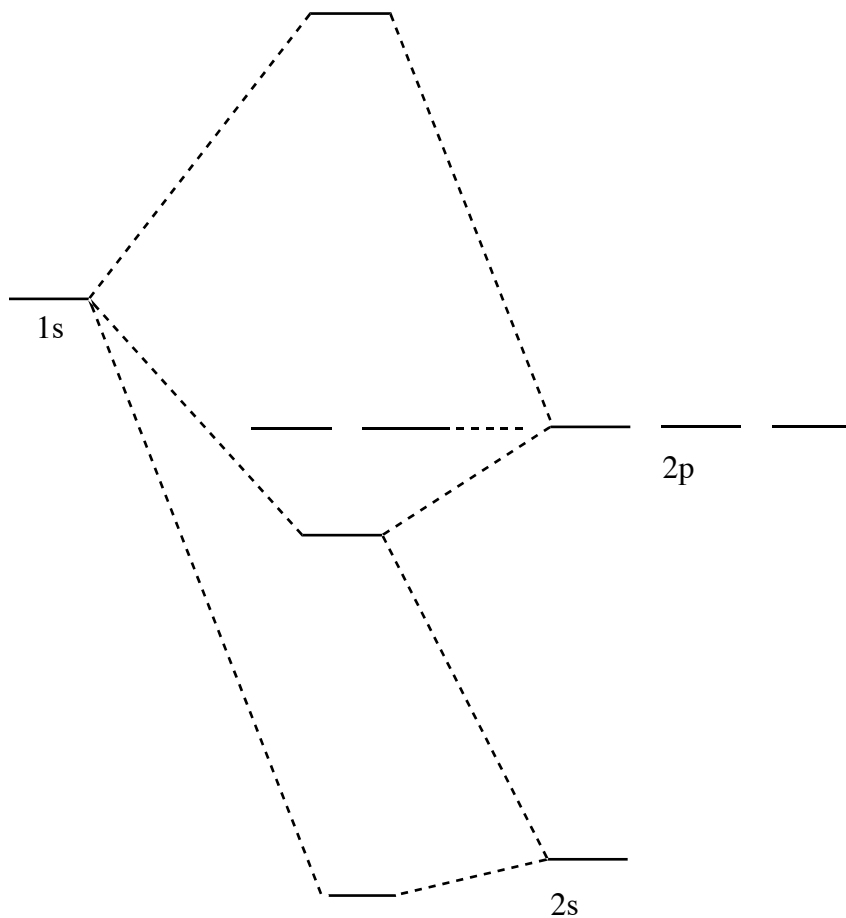
8. (10 pts.) A Lewis acid is an electron pair donor or acceptor?

9. (10 pts.) Ignoring any solvent effects, rank the following bases in order of increasing base strength.
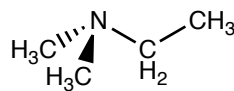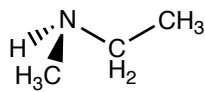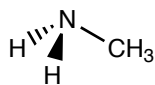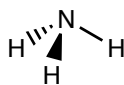
10. (10 pts.) Rank the following acids in order of increasing ability to donate an H^+ and briefly explain your reasoning.

$$HBrO_3 \qquad\qquad HClO_3 \qquad\qquad HIO_3$$

11. (10 pts.) Rank the following acids in order of increasing ability to donate an H^+ and briefly explain your reasoning.

$$HF \qquad\qquad HBr \qquad\qquad HCl \qquad\qquad HI$$

12. (10 pts.) Explain why the molecule drawn below is considered a Brønsted-Lowery super base.
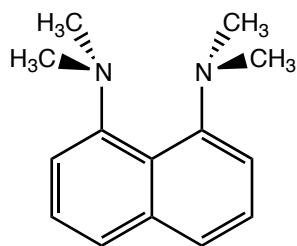
13. (10 pts.) Sulfuric and fluorosulfonic acid are drawn below. Briefly explain why fluorosolfonic acid is the stronger Brønsted-Lowery acid.

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 1.0079																	**He** 4.0026
Li 6.941	**Be** 9.012											**B** 10.811	**C** 12.011	**N** 14.007	**O** 15.999	**F** 18.998	**Ne** 20.1797
Na 22.989	**Mg** 24.305											**Al** 26.981	**Si** 28.086	**P** 30.974	**S** 32.065	**Cl** 35.453	**Ar** 39.948
K	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br** 79.904	**Kr**
Rb	**Sr**	**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
Cs	**Ba**	**La**	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
Fr	**Ra**	**Ac**	**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	110	111	112		114		116		118

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
Th	**Pa**	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**

Atomic numbers: Ce 58, Pr 59, Nd 60, Pm 61, Sm 62, Eu 63, Gd 64, Tb 65, Dy 66, Ho 67, Er 68, Tm 69, Yb 70, Lu 71; Th 90, Pa 91, U 92, Np 93, Pu 94, Am 95, Cm 96, Bk 97, Cf 98, Es 99, Fm 100, Md 101, No 102, Lr 103