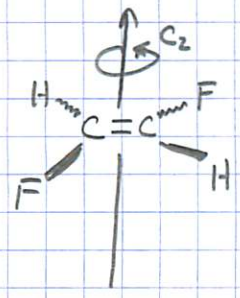
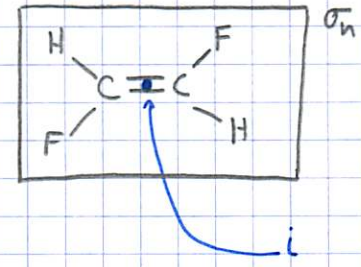
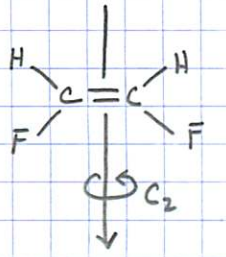
1) All molecules posses E + the symmetry elements highlighted below:

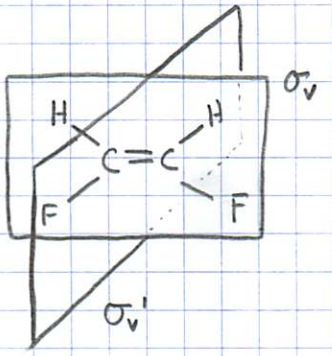
a) 



C_2, σ_h, i (C_{2h})

Achiral

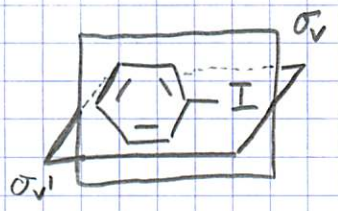
b) 



C_2, σ_v, σ_v' (C_{2v})

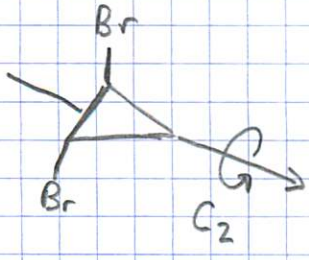
Achiral

c) 



C_2, σ_v, σ_v' (C_{2v})

Achiral

d) 

C_2 Chiral

2. Assign point groups for the following. For cases in which the structure is not drawn, assume the lowest energy conformation.

(a) HF $C_{\infty v}$ (b) NH_3 C_{3v} (c) Toluene C_s (d) O=C=C=C=O $D_{\infty h}$

(e) cubane O_h (f) $W(CO)_6$ O_h (g) Benzene D_{6h} (h) adamantane T_d

(i) P_4 T_d (j) Naphthalene D_{2h} (k) π-bond C_{2v} (l) π-antibond C_{2h}

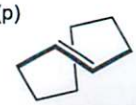
(m) 

D_{5d}

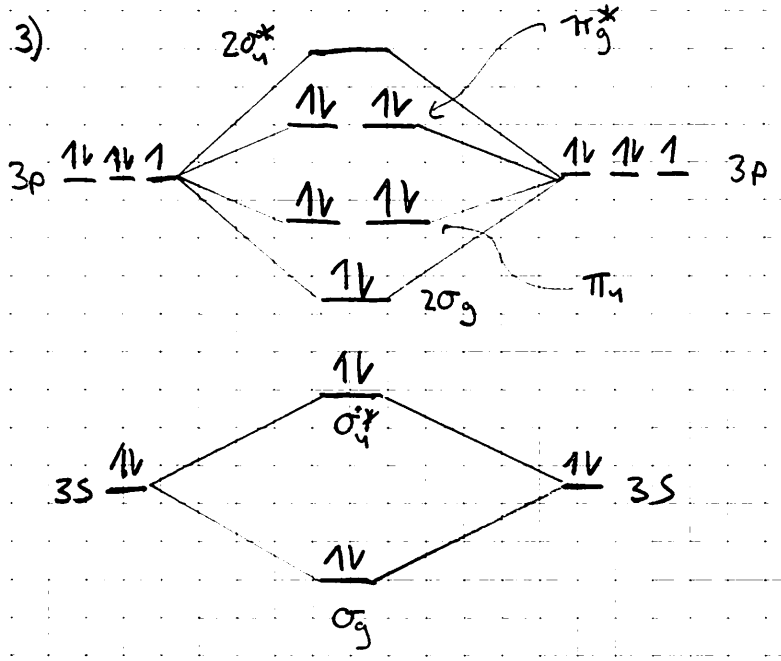
(n) 

D_{5h}

(o) 
D_{2d}

(p) 
C_2

3)

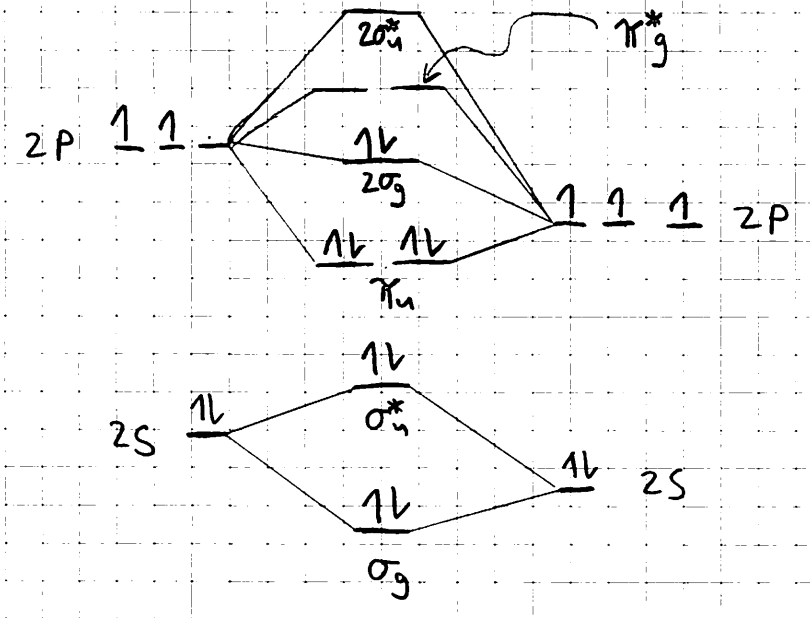


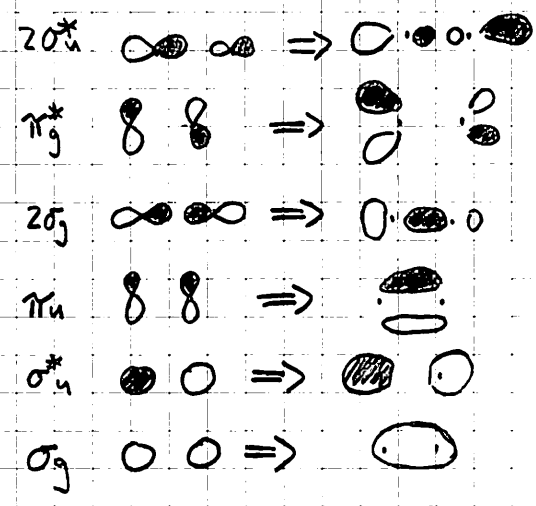
Cl_2 has 4 e^- in the π^* MO + a bond order of 1

Cl_2^+ has 3 e^- in the π^* MO + a BO of 1.5

Since the BO of Cl_2^+ is larger than the BO of Cl_2 the cation should have a shorter Cl–Cl bond length

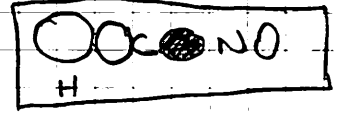
4)



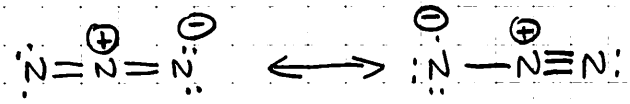


a) BO = 3 because π_u + $2\sigma_g$ are full while π_g^* + $2\sigma_u^*$ are empty.

b) FMO Theory suggests that the HOMO of CO will interact w/ the LUMO of the Lewis acid (H^+). ∴ $2\sigma_g$ of CO will interact with the empty 1s orbital of a proton



5)



- VSEPR suggests N_3 will be linear
- For the representative above, the central N is linearly coordinated & has 2 π-bonds consistent w/ Sp hybridization
- Overall the bonding (By VBT) shows $4 \times \sigma e^-$ + $4 \times \pi e^-$
- There is one unpaired e^- ∴ N_3 is a doublet
- Based on the 2 resonance structures, N_3 is nonpolar
- The bond length of N_2 is shorter than N_3 since the N=N bonds for N_3 have double bond character, & the N≡N bond of N_2 is a triple bond

6)

X-Ray Diffraction - Bond Lengths + Angles

XANES - Oxidation State, geometry + coordination environment

Microwave Spectroscopy - Bond Lengths + Angles

IR Spectroscopy - Bond strength + functional group analysis