MSE160-Mid-Term, Feb 23, 2016

9-11 am

EX 200

Professor Warren Chan

No cell phones

Only a scientific calculator is allowed

(2 points for following instructions on writing the name, section number, and teaching assistant correctly as listed below)

Name (Last Name, First Name):

Section Number:

Teaching Assistant (Last Name, First Name):

Q1: _____ / 8

Q2: _____ / 12

Q3: _____ / 12

Q4: _____ / 10

Q5: _____ / 8

Q6: _____ / 10

Q7: _____ / 6

Q8: _____ / 12

Q9: _____ / 4

Q10: _____ / 6

Q11: _____ / 6

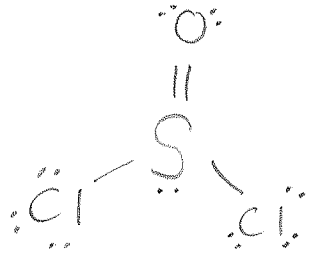
Q12: _____ / 4

Name/Section/TA _____ / 2

TOTAL: _____/100

1. (8 points) Draw the best Lewis Structure and show the calculation of the formal charges and draw all lone electrons to get full credit. Formal charge is equal to valence number – number of bonds – non-bonding electrons.

$SOCl_2$



S: 6 − 2 − 4 = 0

Cl: 7 − 6 − 1 = 0

O: 6 − 4 − 2 = 0

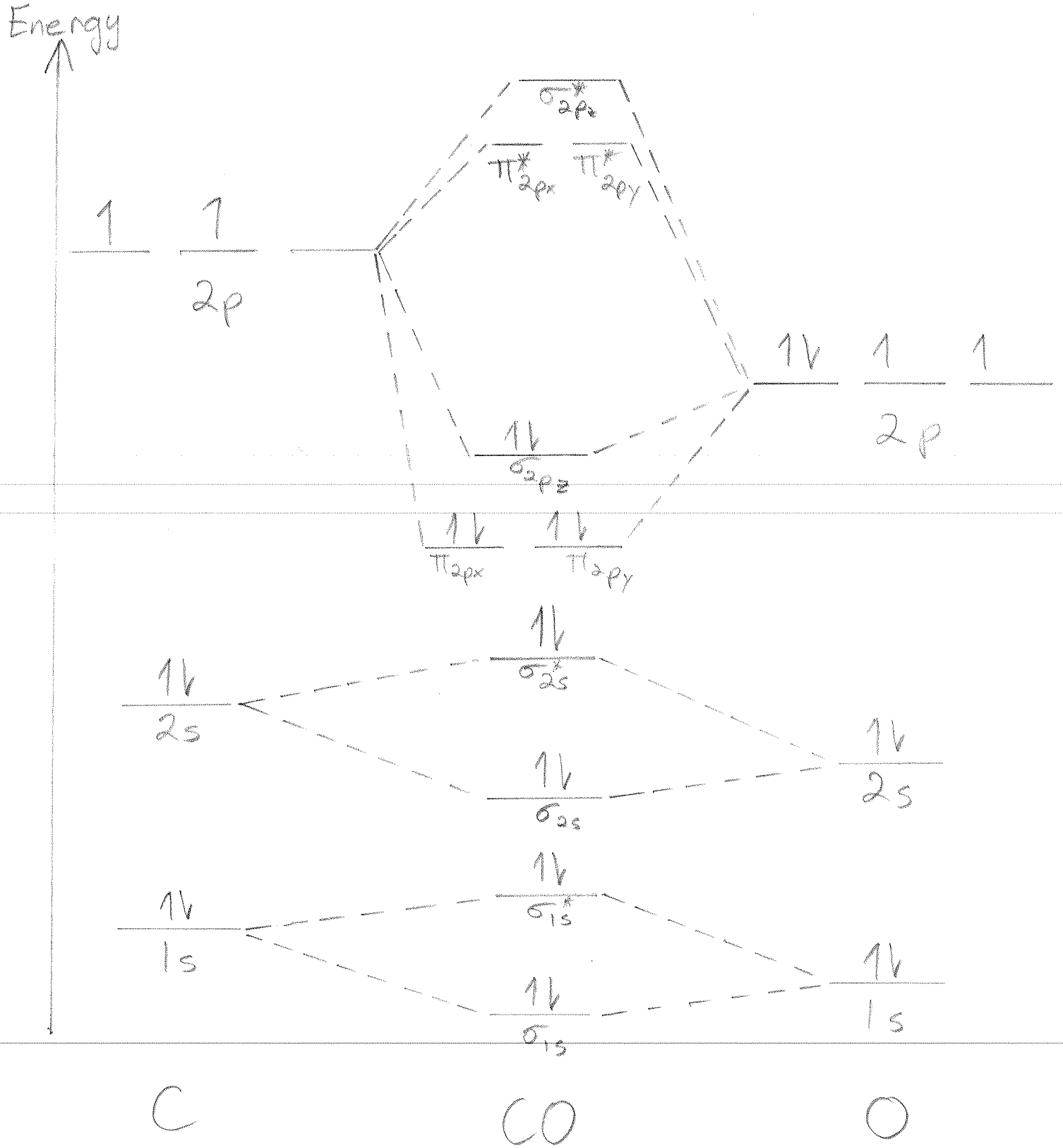
SCN^-

S: 6 − 4 − 2 = 0

C: 4 − 0 − 4 = 0

N: 5 − 4 − 2 = −1

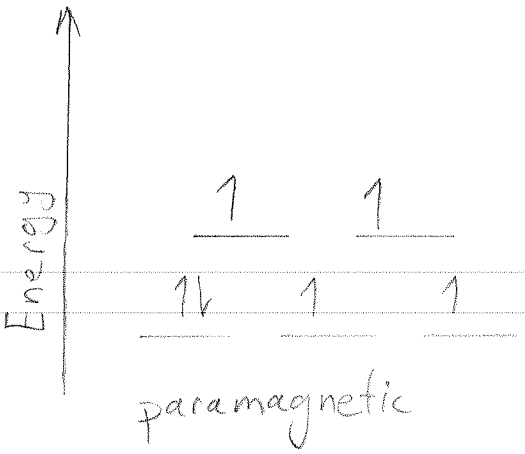
2. (12 points) Using the molecular orbital theory, draw the energy level diagram for CO showing occupation of the orbitals by electrons. Label both atomic and molecular orbitals for full credit.

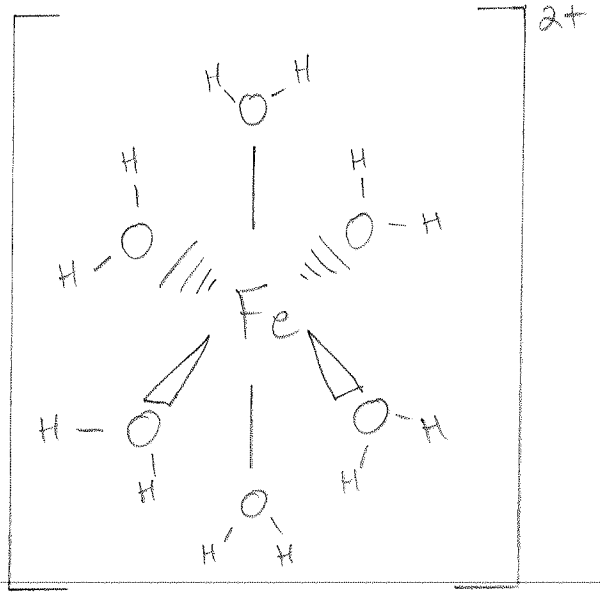


3. (12 points) Draw the crystal splitting energy levels for $[Fe(H_2O)_6]^{2+}$ and $[Fe(CN)_6]^{4-}$. Show the relative difference between the energy gaps in the energy level diagram. Draw the geometry for each complex. Identify whether the molecule is paramagnetic or diamagnetic. Also, fill in the energy levels with electrons for full credit. Hint: $[Fe(H_2O)_6]^{2+}$ has a higher spin than $[Fe(CN)_6]^{4-}$.

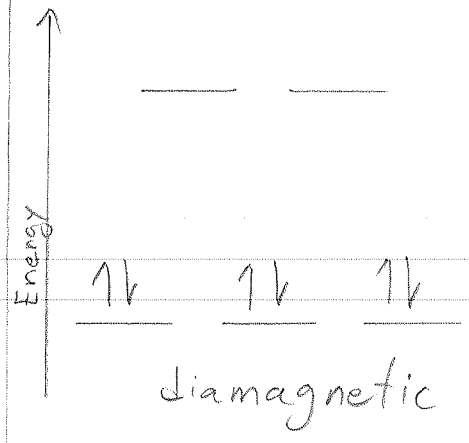
$[Fe(H_2O)_6]^{2+}$
$[Fe(CN)_6]^{4-}$
} $Fe^{2+} \rightarrow d^6$ for both

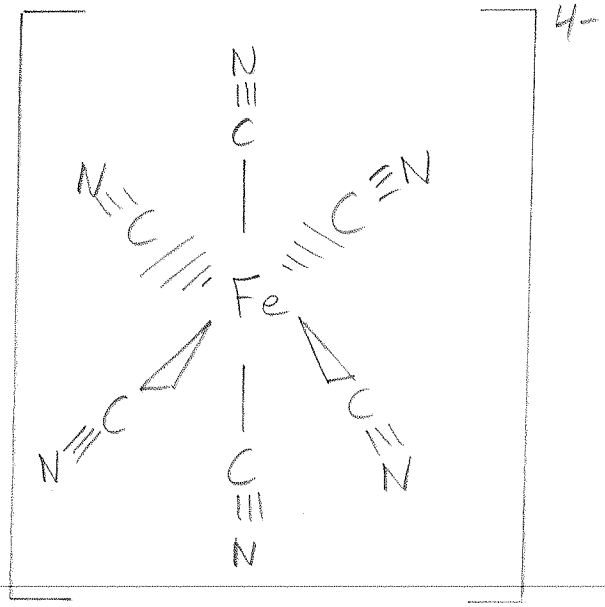
$[Fe(H_2O)_6]^{2+}$





$[Fe(CN)_6]^{4-}$

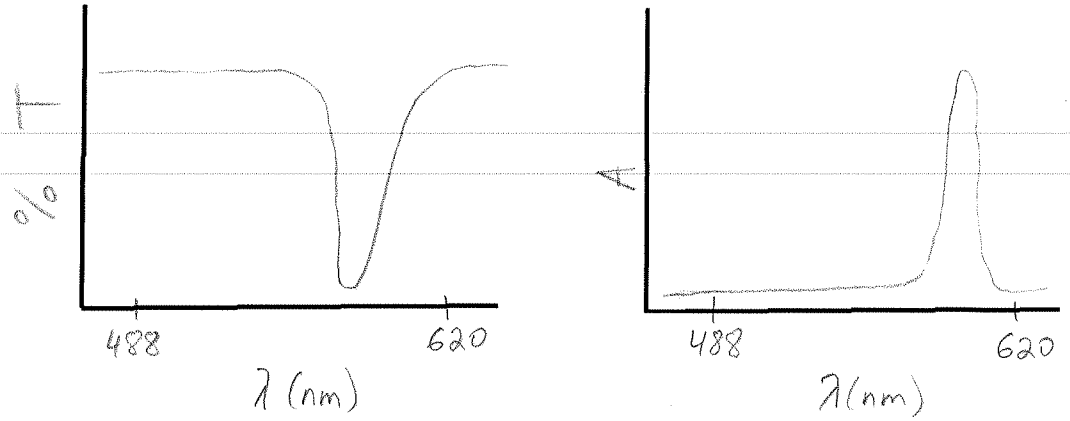




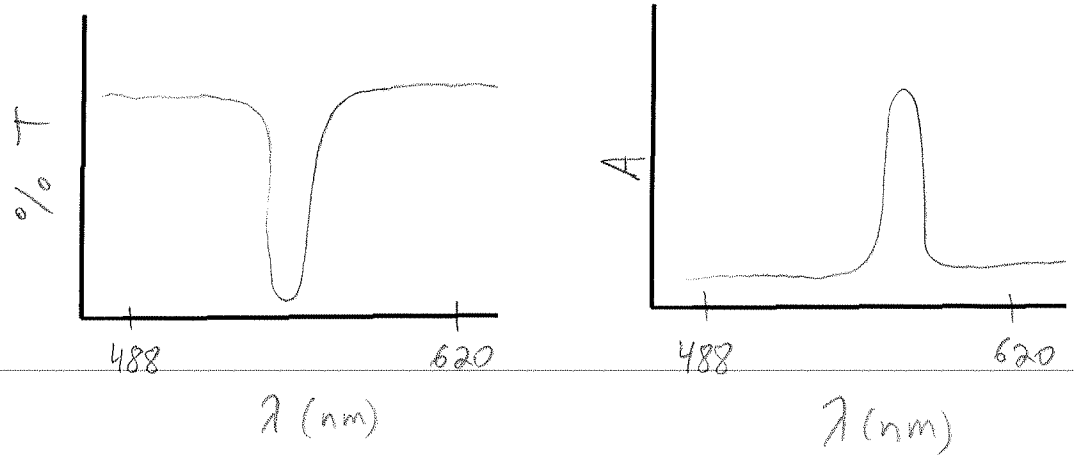
4. (10 points) There is an evil villain that is trying to poison the good people of Toronto. They add 3 different poisons to different parts of Lake Ontario. The Trudeau government got wind of this "operative" by the evil villain and asked Environment Canada to collect water samples from Lake Ontario. These samples will be analyzed to identify the poison. As a first step, they asked you to measure the absorbance of three samples. The three collected samples are from different parts of Lake Ontario and they appeared blue, green, and red. Draw the transmission and absorbance spectra for all three solutions. The data will be sent back to Environment Canada for further evaluation. To obtain full credit, one needs to properly label both the x and y-axis and label the axis with specific numbers that corresponds to the measurements.

Sample	Transmission	Absorbance

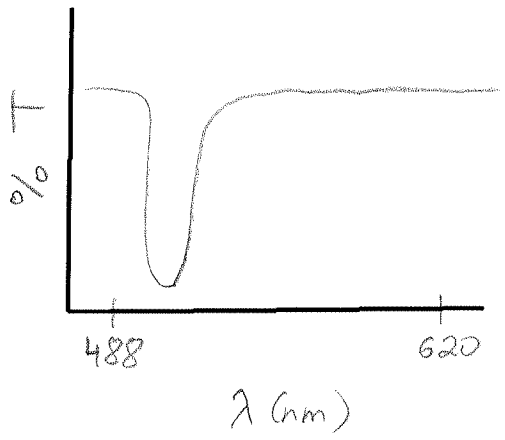
Blue

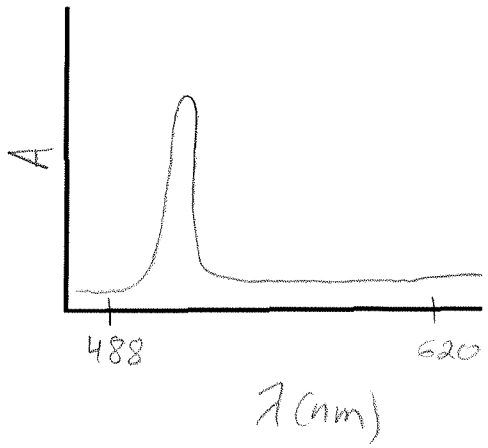


Green



Red





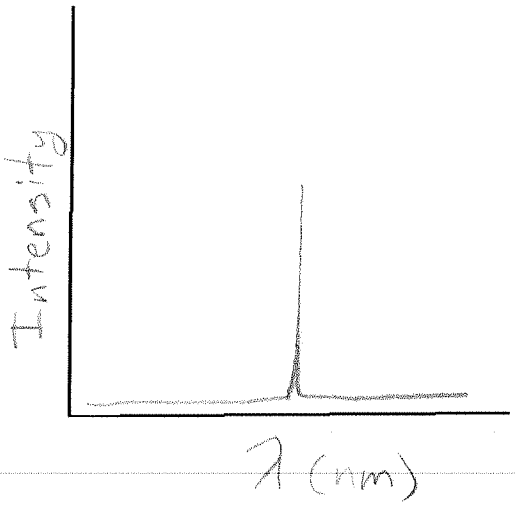
5. (8 points) Write the abbreviated electron configuration for

As $[Ar]\ 4s^2\ 3d^{10}\ 4p^3$

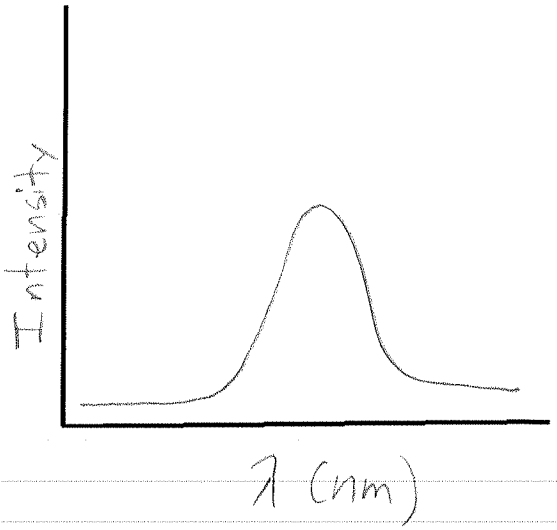
Se^{2-} $[Ar]\ 4s^2\ 3d^{10}\ 4p^6$ ([Kr] also accepted)

6. (10 points) Rydberg described the emission pattern from atoms. Draw the emission spectra for an atom. Interestingly the spectra for a molecule is different than that of an atom. Draw the emission spectra for a molecule. Why is the emission spectral profile different between a molecule and an atom?

Emission spectra for an atom



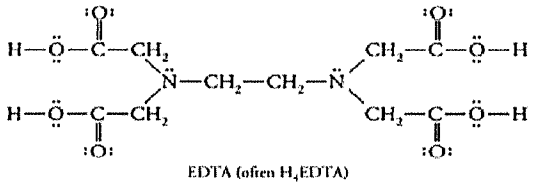
Emission spectra for a molecule



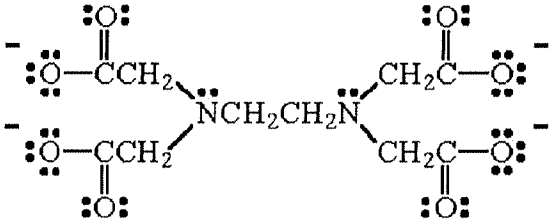
Why is the emission spectral profile different between a molecule and an atom?

Molecules have vibrational bands so electrons have more energy levels to occupy. This is reflected in the broader spectra.

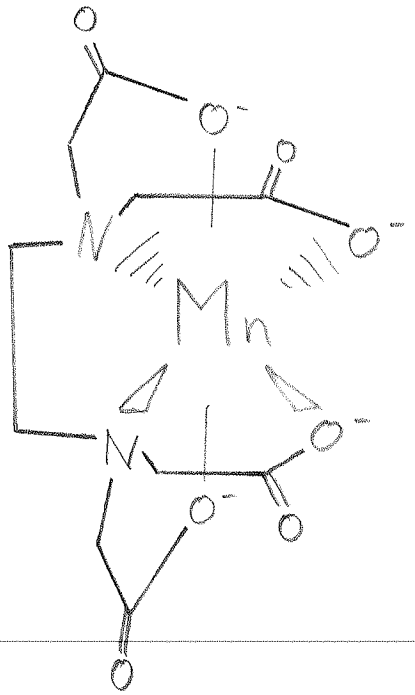
7. (6 points) Draw the metal complex structure of EDTA chelating with Mn(II).
Below are 2 chemical structures for EDTA.



EDTA (often H_4EDTA)

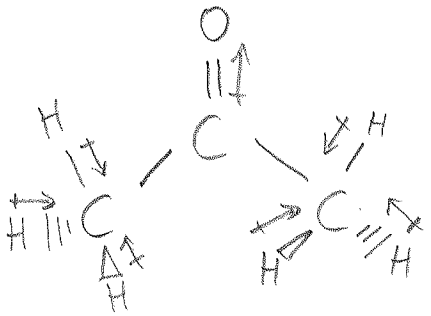


EDTA (Ionic form)



8. (12 points) Acetone is used in paint thinners, nail polish, and many other applications. The chemical structure of acetone is $(CH_3)_2CO$.

a) Draw the three-dimensional shape of this molecule. Draw the appropriate dipoles for each bonds?



b) Give the hybridization of each carbon atom.

left to right: sp^3, sp^2, sp^3

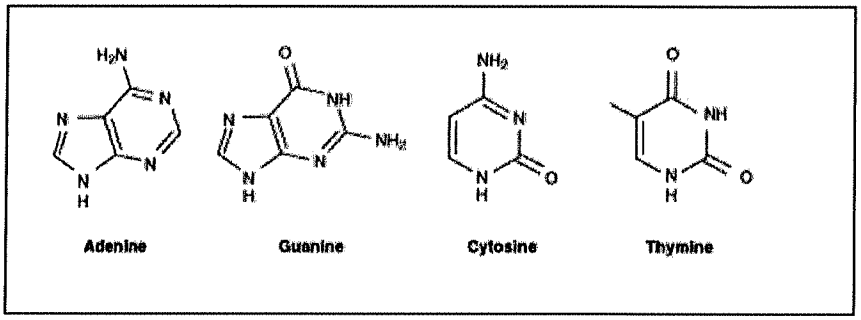
c) Identify any pi orbitals as well as the number of electrons that occupy each one.

There is <u>one</u> pi orbital in the C=O bond occupied by <u>two</u> electrons.

d) Indicate which bonds are IR active.

All bonds

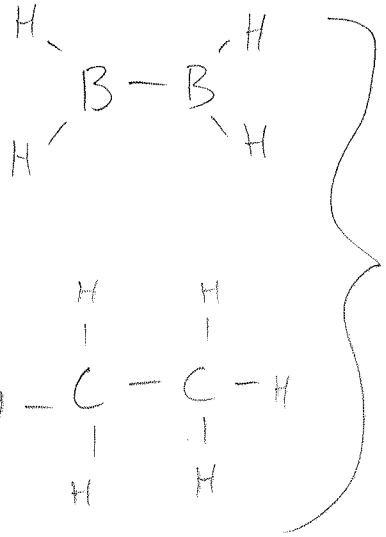
9. (4 points) The equation that determines the melting temperature of DNA (i.e., a temperature which breaks the double-strand into single-strands) is $T_m = 2 \times (A + T) + 4 \times (G + C)$. Why does the interaction of guanine with cytosine contribute more to the melting temperature? T_m refers to the melting temperature. G, C, A, and T are DNA bases and is the abbreviation for guanine, cytosine, adenine, and thymine respectively.



The G-C pairing has more hydrogen bonding than the A-T pairing (3 bonds vs. 2).

This means it takes more energy to break the G-C pairs, thereby contributing more to the melting temperature.

10. (6 points) Which molecules can rotate around the central bond: B_2H_4, C_2H_6, or/and C_2H_4? Please explain why you think 1, 2, or 3 molecules can rotate?

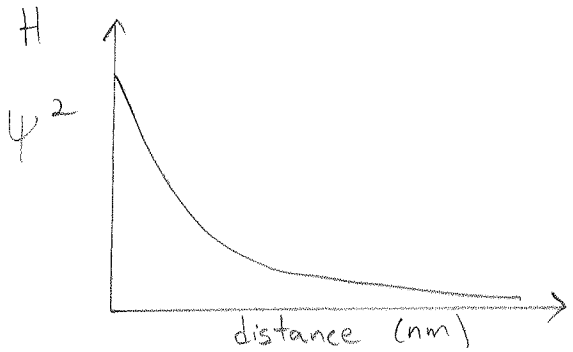


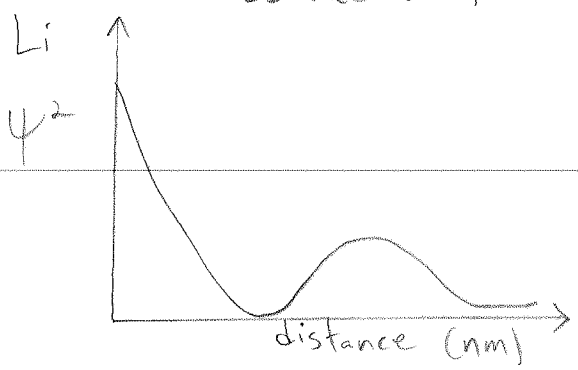
These molecules can because there is only a single bond between the central atoms.

This molecule can't because of the double bond between the central atoms.

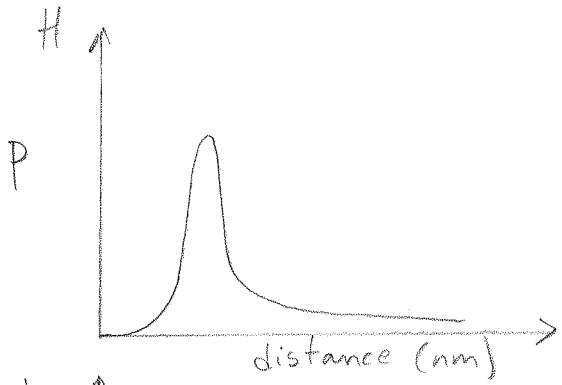
11. (6 points) Draw the radial probability (ψ^2) versus distance from the nucleus for H and for Li. Label all axis appropriately for full credit.

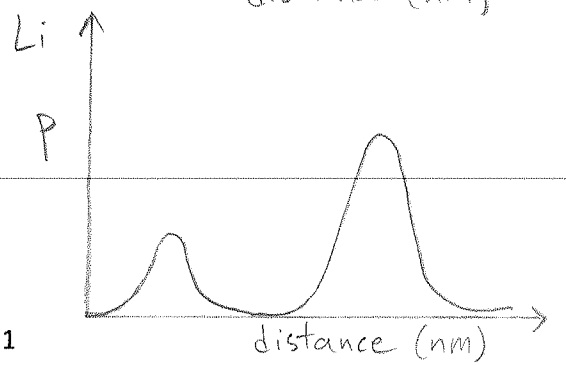
If drawing ψ^2:





If drawing probability ($r^2\psi^2$)





12. (4 points) Name the molecular shape for the two molecules:

PF_5 trigonal bipyramidal

I_3^- linear