Chemistry 101 - Exam III *Name ________________________*
29 November 2017

Show all work for credit. State any assumptions made to solve a problem. Give all numerical answers with the correct number of significant figures. All answers in scientific notation must be in correct scientific notation (i.e., 6.022×10^{23} not 6.022E23 or 6.022e23). All instances of incorrect scientific notation will result in the loss of 3 points each. All numbers that require units should have the units written. All instances of numbers without units will result in the loss of 3 points each.

1. (37 points) A compound of chlorine and fluorine, ClF_n, reacts at about 75°C with uranium metal to produce uranium hexafluoride, UF6, and chlorine monofluoride, ClF(*g*). A quantity of uranium produced 3.53 g UF_6 and 343 mL ClF at 75°C and 2.50 atm. What is the ***formula (n)*** of the compound? ***Describe the bonding*** in the molecule, using valence bond theory (i.e., electron dot structure and geometry).

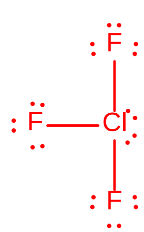
$$n_{Cl} = n_{ClF} = \frac{PV}{RT} = \frac{(2.50\text{ atm})(343\text{ mL})\left(\frac{10^{3}\text{ L}}{1\text{ mL}}\right)}{(0.082058\text{ L atm mol}^{-1}\text{ K}^{-1})(348\text{ K})} = 0.03003\text{ mol}$$

$$n_F = n_{UF_6} \times \frac{6\text{ mol F}}{1\text{ mol UF}_6} + n_{ClF} \times \frac{1\text{ mol F}}{1\text{ mol ClF}} = 3.53\text{ g UF}_6 \times \frac{1\text{ mol UF}_6}{325.01932} \times \frac{6\text{ mol F}}{1\text{ mol UF}_6} + 0.03003\text{ mol ClF} \times \frac{1\text{ mol F}}{1\text{ mol ClF}}$$

$$= 0.09020\text{ mol F}$$

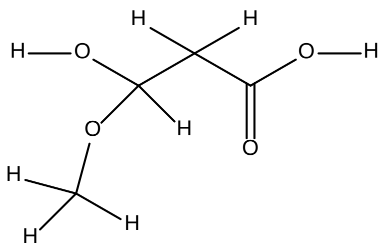
$$n = \frac{n_F}{n_{Cl}} = \frac{0.09020}{0.03003} = 3.004 \approx 3$$

The compound is ClF_3.



EGG = trigonal bipyramidal
MG = T-Shape

2. (30 points) Balance the following reaction and estimate its ***enthalpy of reaction (in kJ)*** using bond energies.



$+ \quad 4 \quad O_2 \rightarrow 4 \quad CO_2 + \quad 4 \quad H_2O$

Break	Make
2 C—C (346 kJ)	8 C=C (799 kJ)
6 C—H (411 kJ)	8 O—H (459 kJ)
4 C—O (358 kJ)	
1 C=O (745 kJ)	
2 O—H (459 kJ)	
4 O=O (494 kJ)	

$$\Delta H \approx \left[(2)(346\text{ kJ})+(6)(411\text{ kJ})+(4)(358\text{ kJ})+(1)(745\text{ kJ})+(2)(459\text{ kJ})+(4)(494\text{ kJ})\right] - \left[(8)(799\text{ kJ})+(8)(459\text{ kJ})\right] = -1835\text{ kJ}$$

3. (30 points) For each of the following diatomic molecules or ions, complete the ***molecular orbital diagram***, calculate the ***bond order*** and determine if each is ***paramagnetic or diamagnetic***.

NF^+

σ_{2s}	σ_{2s}^*	σ_{2p}	π_{2p}	π_{2p}^*	σ_{2p}^*
↑↓	↑↓	↑↓	↑↓ ↑↓	↑	

Paramagnetic $\quad \text{Bond Order} = \frac{1}{2}(B-A) = \frac{1}{2}(8-3) = 2.5$

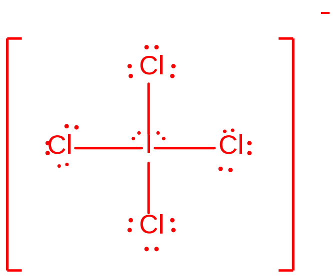
F_2

σ_{2s}	σ_{2s}^*	σ_{2p}	π_{2p}	π_{2p}^*	σ_{2p}^*
↑↓	↑↓	↑↓	↑↓ ↑↓	↑↓ ↑↓	

diamagnetic $\quad \text{Bond Order} = \frac{1}{2}(B-A) = \frac{1}{2}(8-6) = 1$

4. (30 points) For each of the following molecules or ions, draw the ***electron dot structure*** with the optimum formal charges, state the ***electron group and molecular geometries***, determine the ***polarity***, state the ***hybridization*** on the central atom and the number of ***σ and π bonds***.

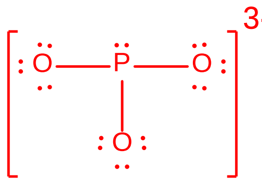
a. ICl_4^-



EGG = octahedral
MG = square planar

Non-polar
sp^3d^2
4 σ, 0 π

b. PO_3^{3-}



EGG = tetrahedral
MG = trigonal pyramidal
polar
sp^3
3 σ, 0 π

5. (23 points) A scientist is looking at the spectrum of Be^{3+} and notices a line in the spectrum at 27.12 nm. If the electron started in the 5th energy level, to which energy level did it drop? What is the energy of the photon?

$$\frac{1}{\lambda}=\frac{Z^2R_H}{hc}\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)$$

$$\frac{1}{n_f^2}=\frac{hc}{\lambda Z^2R_H}+\frac{1}{n_i^2}$$

$$=\frac{\left(6.626\times10^{-34}\text{ J s}\right)\left(2.998\times10^{8}\text{ m s}^{-1}\right)}{\left(27.12\times10^{-9}\text{ m}\right)(4)^2\left(2.180\times10^{-18}\text{ J}\right)}+\frac{1}{(5)^2}=0.24999988$$

$$n_f=\sqrt{\frac{1}{0.24999988}}=2$$

$$E=\frac{hc}{\lambda}=\frac{\left(6.626\times10^{-34}\text{ J s}\right)\left(2.998\times10^{8}\text{ m s}^{-1}\right)}{\left(27.12\times10^{-9}\text{ m}\right)}=7.325\times10^{-18}\text{ J}$$