CHEMISTRY 362

Descriptive Inorganic Chemistry

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Examination I

February 15, 2017

Printed name: _____

Signature: _____

An Aggie does not lie, cheat or steal or tolerate those who do.

Useless Conversion Factors

2000 mockingbirds: 2 kilomockingbirds (work on it....)

10 cards: 1 decacards

1 kilogram of falling figs: 1 Fig Newton

Name: _____ *Chem 362, Exam 1*

February 15, 2017

Question	Points possible	Points received
I	25	
II	24	
III	24	
IV	10	
V	42	
VI	10	
VII	25	
Total	160	

(25 pts)

I. For Hydrogen-like atoms, Ionization Energies:

$$E \propto \frac{-Z^2}{n^2}$$

1. The ionization energy of the 1s electron in ground state Hydrogen atom is 13.6 eV. Calculate the energy required to remove an electron from the n = 2 excited state level of H(g); that is, from n = 2 to n = infinity.

2. The following sets of first and second ionization energies match the two sets of ionization processes, for He and for Li. Match these sets by placing the energy value for each in the space provided. Give a rationale for your choice.

   Set 1: 5.13 eV and 75.6 eV Set 2: 24.6 eV, 54.5 eV

   _____ $He^0(g) + I.E._1 \rightarrow He^+(g) + e^-$

   _____ $He^+(g) + I.E._2 \rightarrow He^{++}(g) + e^-$

   _____ $Li^0(g) + I.E._1 \rightarrow Li^+(g) + e^-$

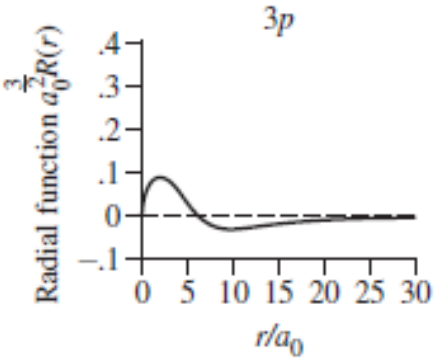
   _____ $Li^+(g) + I.E._2 \rightarrow Li^{++}(g) + e^-$

   Rationale:

3. Using Slater's rules, calculate the Z_{eff} on a <u>3d</u> electron of Ti in oxidation state of +2 vs. that in oxidation state of 0, i.e., Ti^{2+} vs Ti^0. Contrast this to the Z_{eff} on a <u>2s</u> in Ti^0.

(24 pts)

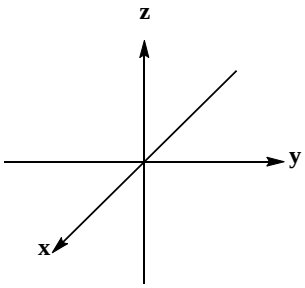
II. 1. The radial function of a **3p** electron is given at right. Superimpose the radial function for the **2p** electron and define the term "radial node" by reference to these plots.



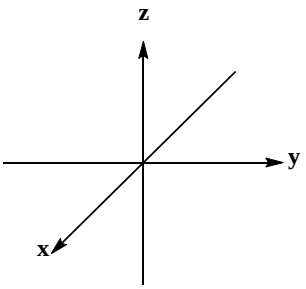
2. How many <u>angular</u> nodes are there in a **2p** orbital? _____; For a **3d** orbital?_____; For a **5s** orbital?_____

3. How many <u>radial</u> nodes are there for a **2p** orbital? _____; For a **3d** orbital?_____; For a **5s** orbital?_____

4. Sketch the shape (the contour plot) of a $\mathbf{2p_z}$ orbital on the coordinate system at right and indicate the phases (the signs on lobes).



5. Sketch the shape of a $\mathbf{3d_{yz}}$ orbital on the coordinate system at right and indicate the signs on lobes.



6. Give the 4 quantum numbers, n, l, m_l, and m_s, for the highest energy electron added to Ti^0.

(24 pts)

III. 1. Give ground state electronic configurations of the underlined atom for the following, using core notation [inert gas] $ns^{?}\ np^{?}$, etc.

a. $\underline{Cr}^{0}(g)$ _____

b. $\underline{Cr}Cl_3$ _____

c. $\underline{C}rO_4^{2-}$ _____

2. The ground state term symbol of Cr^{o} (g) is ^{7}S. Give the box diagram for the valence electrons, with m_l and m_s values that account for this term symbol, i.e, show how the term symbol is derived. Calculate its spin-only magnetic moment.

3. What is the spin multiplicity and the ground state term symbol of Cr^{3+} in $CrCl_3$? Calculate its spin-only magnetic moment.

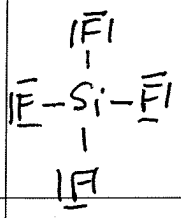
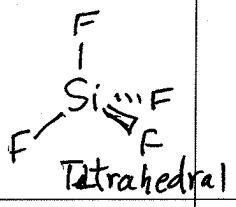
(10 pts)

IV. List the oxidation states of the central atom in CO_2, CO_3^{2-}, NO_2^{-} and NO_3^{-}? Give the Lewis structures of all and, by use of formal charges, illustrate that you can choose between two possible resonance forms of the NO_2^{-} anion.

	$\underline{C}O_2$	$\underline{C}O_3^{2-}$	$\underline{N}O_2^{-}$	$\underline{N}O_3^{-}$
Ox. State	____	____	___	____

(42 points)

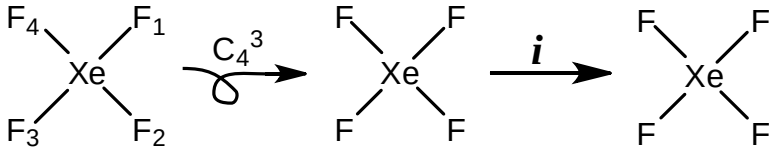
V. Fill in the boxes in the following table.

	Lewis Structure & oxidation state of central atom	Geometrical Structure (VSEPR prediction)	Hybrid orbitals used by central (underlined) atom	Principal Rotation Axis C_n	Inversion Center, i?	Point Group
$\underline{Si}F_4$		 Tetrahedral	sp^3	C_3	No	Td
$Cl\underline{Si}F_3$						
$\underline{S}F_4$						
$\underline{S}F_6$						
$\underline{S}O_3^{2-}$						
$\underline{B}Cl_3$						
$\underline{B}ClF_2$						

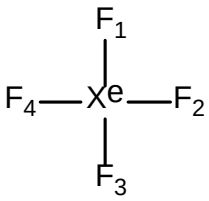
(10 points)

VI. a) Show by means of labels, drawings, and atom position change, the following symmetry operations:

A C_4 rotation (use **clockwise** rotation) followed by an inversion on square planar XeF_4



A rotation about a C_2 axis that is perpendicular to the C_4 principal axis (indicate the particular C2 you selected to use as example).



(25 points)

VII. Consider the following structures. a) is the staggered form of ethane; b) is the eclipsed form; c) is an octahedron perhaps representing SF_6. d) is a trigonal species such as BF_3, NO_3^-, or SO_3. e) is benzene; f) is borazine (isoelectronic and isostructural with benzene). Use these structures to answer the following questions about symmetry:

i. Which structure(s) does not (do not) contain an inversion center? _____
ii. Which structure(s) contain a C_3 rotation axis? _____
iii. Which structure (there is only one) does <u>not</u> contain a σ_h? _____
iv. Which ethane structure has an S_{2n} symmetry element (i.e., a C_n followed by reflection in σ_h). Which one is it and what is n? _____
v. Which ethane structure has an inversion center? _____
vi. How many C_6 operations are there in benzene? ____; in borazine?_____
vii. How many C_3 operations are there in benzene? ____; in borazine?_____
viii. How many σ_v are in benzene? ____; in borazine?_____

a) b) c) d) e) f)