1.(30 pts)

(a) How many electrons can have each of the following sets of quantum numbers? (10 points)

10

$n=0, l=0, m_l=0, m_s = ½$

none $n \neq 0$ for all e-

$n=4, l=2, m_l=-1$

two

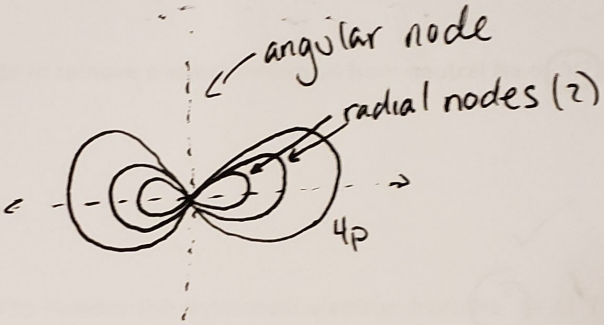
(b) Which of the following sets of quantum numbers is valid? If the set is valid, draw the corresponding orbital, and label the angular and radial nodes. If the set is invalid, explain why it is invalid. (10 points)

10

$(4, 1, -1, -½)$
valid

n-l-1 radial nodes = 2

& angular nodes = 1



$(3, 3, -1, ½)$

invalid because l is restricted to $\{0, 1, 2, \ldots, n-1\}$ and $3 = n \neq l$ in this case. $l \leq n-1$, for all valid sets of quantum #s

(c) If an electron has the quantum numbers (4,1,1, 1/2), in a 2 electron system, what is the m_s value for the second electron? What is the multiplicity for the 2 electron system? (10 points)

10

$m_s = +\frac{1}{2}$

OK

Multiplicity = $2s+1 = 2(1)+1 = 3$
triplet

2. (40 pts)

(a) List the electron configuration for the following by using a noble gas to represent the closed shell core electrons: (15 points)

Sb^+ $[Kr]\ 5s^2 4d^{10} 5p^2$ ✓

Al $[Ne]\ 3s^2 3p^1$ ✓

Ca^{2+} $[Ne]\ 3s^2 3p^6$ ✓

(b) Will it take more energy to remove a valence electron from neutral Na or Al? **(circle one)** (10 points) ✓

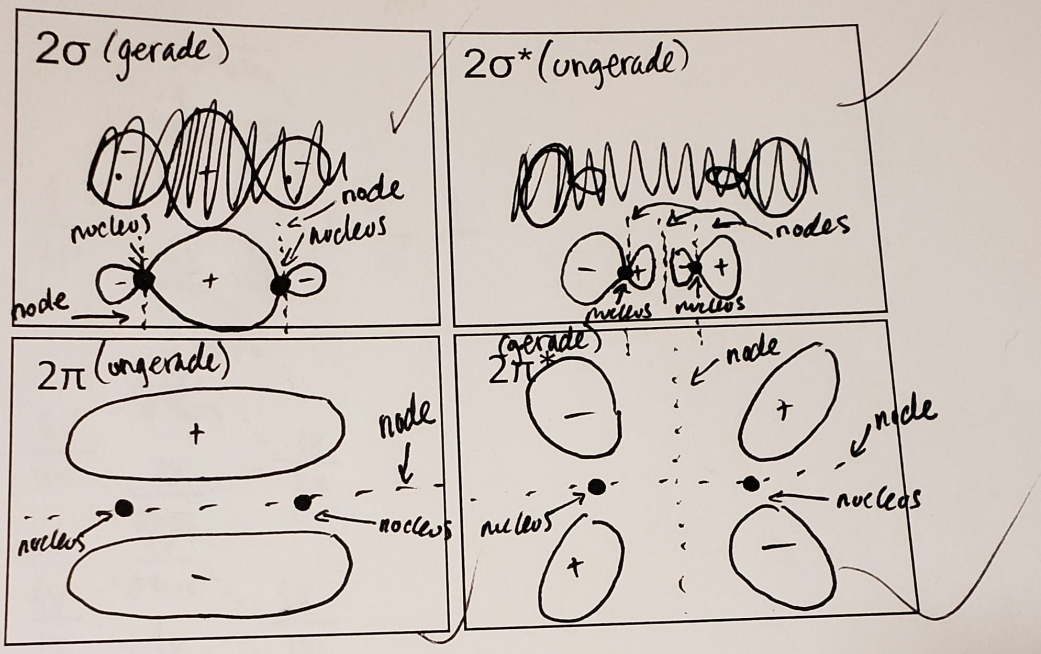
(c) Will it take more energy to remove the outermost electron from Na^+ or Al^+? **(circle one)** (10 points) ✓

Please explain your answer to part (c). **Anything written past the third line will not be considered as part of your answer** (5 points) ✓

Na^+ has noble gas configuration while Al^+ does not, so the outermost electron of Al^+ experiences a smaller electrostatic force with the nucleus than Na^+, giving it a lower IE.

3. (70 pts)

(a) Draw the σ, σ*, π, and π* orbitals that result from combining the 2p orbitals of Cl_2. Label the nuclei, label whether they are gerade or ungerade, and label any nodes. (40 points)



(b) Rank the molecular orbitals in part (a) from lowest ionization energy to highest ionization energy (write σ, σ*, π, π* in order from lowest to highest IE on the line provided. (20 points)

σ, π, π*, σ*

Lowest IE

Highest IE

(c) What laboratory technique is used to measure ionization energy? (10 points)

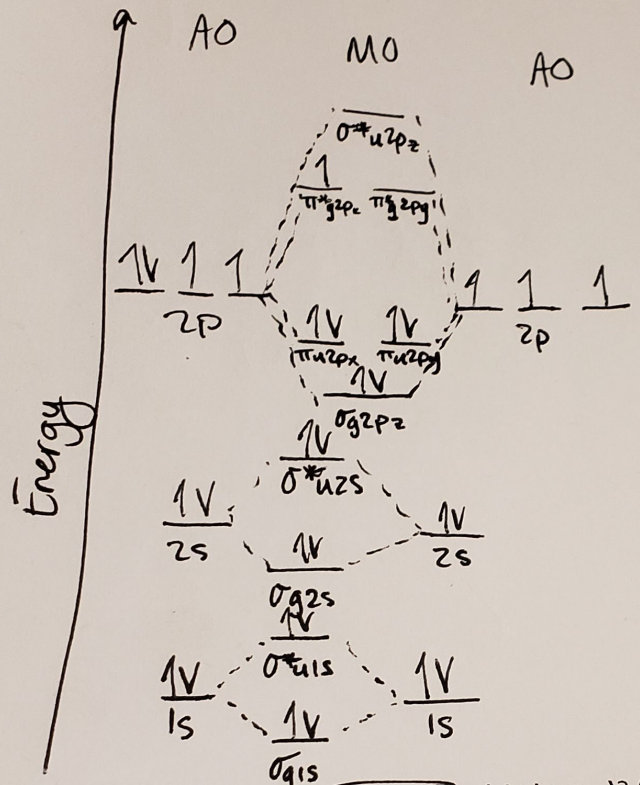
Photoelectron Spectroscopy

10

10/60

4. (60 pts)

(a) Draw the complete MO diagram of O_2^+ (35 points)



35

(b) Is O_2^+ diamagnetic or paramagnetic **(circle one)**? (10 points)

10

(c) Would O_2 have stronger or weaker bonds than O_2^+? How can you tell? (15 points)

15

Provide your answer in two sentences or less, anything written past the fourth line will not be considered as part of your answer:

O_2 would have weaker bonds than O_2^+ because it has a lower bond order. $BO_{O_2^+} = \frac{1}{2}(6-1) = 2.5$

$BO_{O_2} = \frac{1}{2}(6-2) = 2 < 2.5$