CHEM 121
Spring 2006
Quiz 3

Name: ____

1. (4 Points) Which has the larger electron affinity, the oxygen atom or the O^- ion? Explain.

The oxygen atom has the larger electron affinity. More energy is required to add an electron to O^- to overcome the larger repulsive interaction between the negatively charged O^- ion and the incoming electron. There will also be an increase in electron-electron repulsion when an electron is added to O^- which will destabilize the product (O^{2-}) and means that more energy must be expended to place an electron on O^-. Recalling that the electron affinity is defined as the amount of energy given off when an electron is added, this means that the electron affinity of O will be larger than that of O- because energy will released when an electron is added to O, but energy is required when an electron is added to O^-.

Note that the fact that adding an electron to O^- leads to a full p subshell does not affect the electron affinity all that much. It will stabilize O^{2-}, thus leading to less energy being required to put an electron on O^-, but it is overwhelmed by the Coulombic repulsive interactions.

2. (4 Points) Sometimes the electronic configurations of the p-block elements of the fourth period and higher are written as "$ns^2\ np^x$", omitting the $(n-1)$d. Explain why this can be done.

Once the d orbitals are filled (as is the case for the p-block metals of the fourth period and higher) they become core electrons and are no longer valence electrons. Because they no longer play a role in the chemistry of the p-block elements, they are omitted from the electron configuration of these elements.

3. (4 Points) Explain why Al^{4+} ion does not exist under standard conditions.

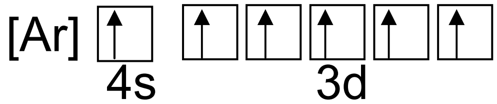
The fourth ionization energy of Al is very high because it requires removal of a core electron with a principle quantum number of $n = 2$. Under standard conditions there is simply not enough energy available from the surroundings to force this ionization to occur. And therefore, the Al^{4+} ion does not exist under standard conditions.

Note that the Al^{4+} can, and does exist, under conditions where there is enough energy available to cause this ionization to occur. Remember that stability is a thermodynamic concept, and that stability is <u>always</u> relative. Under standard conditions there is not enough energy available from the surroundings to form Al^{4+}, and if we did have some Al^{4+} then the direction of spontaneous change would be to form Al^{3+}. If we changed the conditions (i. e., temperature) such that there was enough energy in the surroundings, then direction of spontaneous change would be toward Al^{4+}, not Al^{3+}.

Continued on reverse →

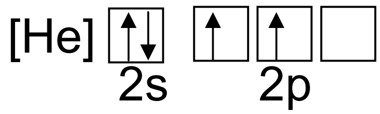
4. (10 Points) Using orbital box notation, give the electronic configuration of the following species. Indicate which species are paramagnetic and which are diamagnetic.

Cr



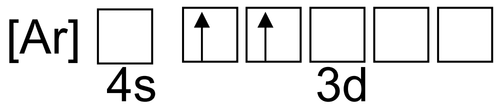
paramagnetic

C



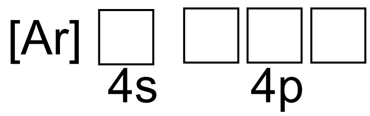
paramagnetic

V^{3+}



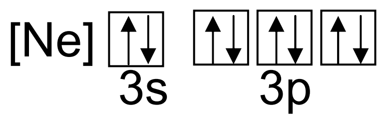
paramagnetic

Ga^{3+}



diamagnetic

S^{2-}



diamagnetic

Note for Ga^{3+} the filled 3d subshell was omitted because it is no longer in the valence. Its electronic configuration looks a little weird because Ar would not normally have the 3d subshell filled (it is there, there just aren't any electrons in it). You could have shown the filled 3d or omitted them, and received full credit.

5. (8 Points) Given below are an elemental property and a group of atoms and/or ions. Arrange each group in increasing order of the property. For example, if the property were size and the species were Xe, He, Kr, and Ar then the answer would be He, Ar, Kr, Xe.

a. Electron affinity. F, Cl, Br, I

I, Br, Cl, F *(Electron affinity decreases down a group.)*

b. Size: K^+, Ar, Cl^-, S^{2-}

K^+, Ar, Cl^-, S^{2-} *(All have the same electronic configuration. K^+ has a positive charge so all the electrons are pulled in more than the others, and so it is smaller than Ar (and is thus the smallest). Cl^- and S^{2-} ions have negative charges, and because there is more electron-electron repulsion, they are bigger than Ar. Because S^{2-} has a larger charge than Cl^-, it must be bigger than Cl^- (and is thus the largest).)*

c. Ionization energy: In, P, Ar

In, P, Ar *(Ionization energy decreases down a group and is generally smaller for metals, like In, than for nonmetals. P is a nonmetal with a half-filled p subshell, and is expected to have a relatively high ionization energy, but not as high as Ar. Ar is to the right of P, and as ionization energy increases across a period, we expect it to have a higher ionization energy than P (and thus the largest of the group).)*

d. Ionic radius: V^{2+}, V^{3+}, V^{4+}

V^{4+}, V^{3+}, V^{2+} *(Ionic radius increases for cations as the charge decreases because the electrons are less tightly held.)*

6. (6 Points) Problem 4-42.

Determine the amount (moles) of NaOH. Since KHP is a monoprotic acid and NaOH is a monoprotic base, the stoichiometry is 1:1.

$$0.1082 \text{ g KHP}\left(\frac{1 \text{ mole KHP}}{204.22 \text{ g KHP}}\right)\left(\frac{1 \text{ mole NaOH}}{1 \text{ mole KHP}}\right) = 5.298_2 \text{x}10^{-4} \text{ mole NaOH}$$

Find the concentration from the number of moles and the solution's volume.

$$\frac{5.298_2 \text{x}10^{-4} \text{ mole NaOH}}{20.46\text{x}10^{-3} \text{ L}} = 0.02590 \text{ M NaOH}$$

The concentration of the NaOH solution is 0.02590 M.