Chemistry 105
Homework Set # 4 (25 points)}
Due Monday, November 15 (Drop off SC 218, fax to: 630-617-6441 or e-mail.)

1. Describe each of the following types of bonding found in solids (see discussion 6):
   (a) ionic
   Ionic bonding results from attractive interactions from oppositely charged ions. Positively charged ions and negatively charged ions form a solid state compound
   (b) covalent network bonding
   Covalent network solids consist of a "net" of atoms held together by covalent bonds. Electrons are shared in this form of bonding.
   (c) metallic bonding
   In metallic bonding, metal atoms are linked by electrons that are distributed throughout the solid. Imagine an array of positive nuclei, all sharing a "sea" of electrons. This is different from covalent bonding, in which electrons are considered to be shared locally between two atoms.
   (d) van der Waals bonding
   van der Waals bonding is a type of attractive force that results from induced polarization of electron clouds. This type of interaction is much weaker than the others mentioned above.

2. What is the pH of each solution below? Identify the solution as acidic, basic or neutral. (Text, chpt 7)
   (a) $[H_3O^+] = 1.0 \times 10^{-5}$ **pH = 5, acidic**
   (b) $[H_3O^+] = 1.0 \times 10^{-9}$ **pH = 9, basic**

3. Write a balanced acid dissociation equation for the following acids:
   Example: For sulfuric acid H_2SO_4, one would write: $H_2SO_4 + 2H_2O \longrightarrow 2H_2O^+ + SO_4^{2-}$
   (a) HI
   $$HI + H_2O \longrightarrow H_3O^+ + I^-$$
   (b) HNO_3
   $$HNO_3 + H_2O \longrightarrow H_3O^+ + NO_3^-$$
   (c) H_2CO_3
   $$H_CO_3 + 2H_2O \longrightarrow 2H_3O^+ + CO_3^{2-}$$
   Also OK (this is for single dissociation):
   $$H_CO_3 + H_2O \longrightarrow H_3O^+ + HCO_3^-$$

4. Identify the acid and base in each equation. In the space provided, write a complete, balanced equation for the acid/base neutralization reaction between the two species:
   (a) NaOH (base) and HBr (acid)
   $$NaOH + HBr \longrightarrow H_2O + NaBr$$
   (b) H_3PO_4 (acid) and LiOH (base)
   $$H_3PO_4 + 3LiOH \longrightarrow 3H_2O + Li_3PO_4$$
   (c) HNO_3 (acid) and $Mg(OH)_2$ (base)
   $$2HNO_3 + Mg(OH)_2 \longrightarrow 2H_2O + Mg(NO_3)_2$$

5. Calculate the molar mass of N_2H_4.

$$molar\ mass = 2(14.01\ g) + 4(1.01\ g) = 32.06\ g$$

6. Calculate the molar mass of CH_3Cl.

$$molar\ mass = 12.01\ g + 3(1.01\ g) + 35.45\ g = 50.49\ g$$

7. Calculate the molar mass of NI_3.

$$molar\ mass = 14.01\ g + 3(126.90\ g) = 394.71\ g$$

8. How many moles of CH_3Cl are there in 75.0 g?

$$\frac{75.0\ g}{} \times \frac{1\ mole}{50.49\ g} = 1.49\ moles$$

9. How many moles of N_2H_4 are there in 25.8 g?

$$\frac{25.8\ g}{} \times \frac{1\ mole}{32.06\ g} = 0.805\ moles$$

10. Calculate the number of grams in 3.25 moles of NI_3.

$$\frac{3.25\ moles}{} \times \frac{394.71\ g}{1\ mole} = 1283\ g = 1.28\ kg$$

11. Suppose you need 0.0519 moles of $Ca(OH)_2$. How many <u>milligrams</u> would you need to weigh out?

$$molar\ mass = 40.08\ g + 2(16.00\ g) + 2(1.01\ g) = 74.10\ g$$

$$\frac{0.0519\ moles}{} \times \frac{74.10\ g}{1\ mole} \times \frac{1000\ mg}{1\ g} = 3850\ mg$$

12. How many valence electrons do the following ions have?

(a) Ti^{2+} **2**
(b) Fe^{3+} **5**
(c) Cu^{2+} **9**
(d) Cr^{4+} **2**
(e) Ta^{2+} **3**

13. For the following gemstones, identify the mechanism of color production, and what chemical species is responsible.
Example: Ruby - the red color comes from d to d transitions in the Cr^{3+} impurites in the mineral corundum.

(a) Blue diamonds
The blue color comes from boron impurities in the the diamond form of elemental carbon. Boron creates a low energy acceptor band for electrons. Transitions between the valence band and acceptor band require photons in the red/orange region, leading to a blue color.

(b) Emeralds
The bright green color comes from d to d transitions in the Cr^{3+} impurites in the mineral beryl.

(c) Aquamarine
The blue-green color comes from d to d transitions in the Fe^{2+} impurites in the mineral beryl.

(d) Sapphires
The blue color comes from charge transfer transitions between Ti^{3+} and Fe^{3+} impurites in the mineral corundum.

14. Given the discussions regarding the spectrophotochemical series in Discussion 9, arrange these species in terms of increasing energy differences between the HOMO and LUMO: $[Co(NH_3)_6]^{3+}$, $[Co(Cl)_6]^{3-}$ and $[Co(CN)_6]^{3-}$.

    $[Co(Cl)_6]^{3-}$ *smallest*

    $[Co(NH_3)_6]^{3+}$

    $[Co(CN)_6]^{3-}$.*largest*

15. Given your answer to the last question, arrange these species in terms of increasing wavelengths for the longest wavelength transition: $[Co(NH_3)_6]^{3+}$, $[Co(Cl)_6]^{3-}$ and $[Co(CN)_6]^{3-}$.

    $[Co(CN)_6]^{3-}$.*shortest wavelength, largest E*

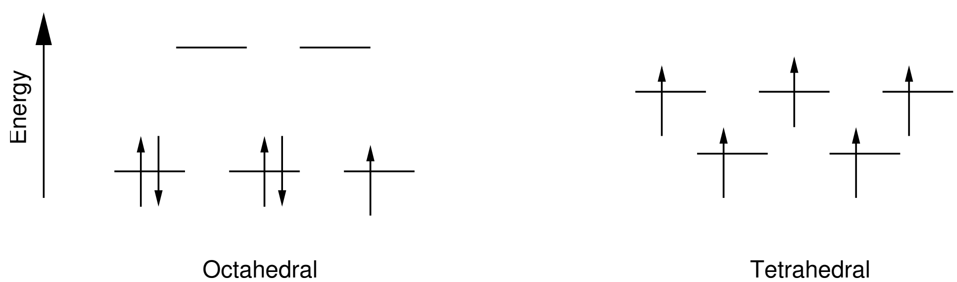
    $[Co(NH_3)_6]^{3+}$

    $[Co(Cl)_6]^{3-}$ *longest wavelength, smallest E*

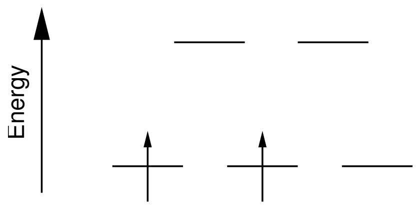
16. The following are d orbital diagrams for octahedral and tetrahedral transition metal complexes. Fill in the electrons for each of the following transition metal ions.

    Note that on all of these, I have paired electrons in the octahedral cases, and left them unpaired in the tetrahedral cases. This depends somewhat on the ligand involved. For tetrahedral complexes, it is usually the case that the difference in E is so small that it cost more to pair the electrons. This is the case for some octahedral complexes as well. In this question, I am not looking for something so subtle. I am really looking for four more basic things: (1) putting the correct number of valence electrons in the diagram (2) putting no more than two electrons in a given orbital (3) having the spins of two electrons in the same orbital be in different directions and (4) filling or partially filling the lower orbitals before the upper ones.

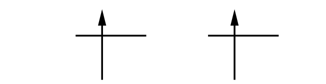
    (a) *Mn*$^{2+}$ **5 valence electrons**



(b) Ta^{3+} **2 valence electrons**

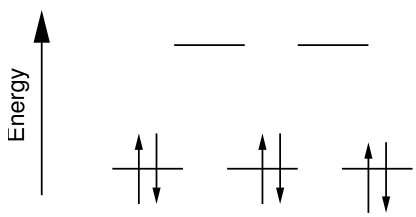


Octahedral

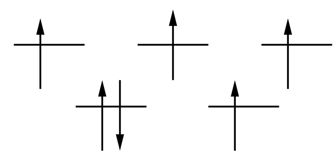


Tetrahedral

(c) Co^{3+} **6 valence electrons**



Octahedral



Tetrahedral