CH101 Fall 2018
Discussion #7
Chapter 6

Name: _____ TF's name:_____ Discussion Time: _____

Things you should know when you leave Discussion today:

- Dissolving ionic, polar, and non-polar compounds in water Mahaffy, 2e section 6.5
- Chemical reactions in water. Mahaffy, 2e section 6.6 -6.7
- Precipitation Reaction & Solubility Solubility of Ionic compounds
- Molar Concentration (Molarity) Mahaffy, 2e section 6.8

1. Calculate the maximum number of moles of hydrogen bonds that can form in a sample of 68 g of pure liquid ammonia, NH_3.

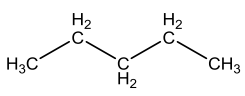
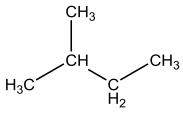
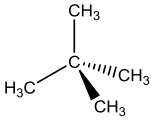
   a. How many hydrogen bonds will be in 24 Liters of gaseous ammonia?

2. Consider that melting or evaporating of H_2O is primarily due to breaking hydrogen bonds.

   a. Water at 0°C only contains 1.80 moles of hydrogen bonds per mole of H_2O. If it takes 5.25 kJ to melt one mole of ice, calculate the energy required to break one mole of hydrogen bonds. (*At home: calculate how much energy is required to break an individual hydrogen bond.)*

   b. Water at 100°C has 1.6 moles of hydrogen bonds per mole of H_2O. Assuming that all the heat is used only to break hydrogen bonds, predict the value of $\Delta_{vap}H$ in kJ/mol of H_2O. ***Hint:*** *how many hydrogen bonds remain in water vapor? Define enthalpy of vaporization*.

3. For each group, circle the compound that has the highest boiling point. Justify your answers.

Group 1:	He	Al	H_2O
Group 2:	CH_4	CH_3OH	N_2
Group 3:	NH_3	NI_3	BH_3
Group 4:			

4. The molarity is a unit of concentration and is defined as the moles of a solute in one liter of solvent$\left(\frac{\text{moles of solute}}{\text{L of solvent}}\right)$. Using dimensional analysis and the density of water (1.00 g/mL), calculate the molarity of pure water.

5. A computer simulation at 25°C of $BaCl_2(s)$ dissolved in water. A cubical region will containing on average 110 water molecules, three Ba^{2+} ions and six Cl^- ions. What is the concentration (in *M*) of the chloride ion in the solution? ***Hint:*** *Assume that the density of water is 1 g/mL.*

6. You are given 300. mL of a 0.2 M aqueous solution of calcium chloride ($CaCl_2$; 111g/mol) and 300. mL of a 0.2 M aqueous solution of sodium phosphate (Na_3PO_4; 164 g/mol). These solutions are mixed and a precipitate forms.

    a. List all the species in each of the solutions and the amount of each species. (always write the phase/state of the compound next to the chemical symbol, e.g. H_2O (l) for liquid water)

    b. List all the species in the combine solution before reaction :

    c. What are the spectator ions for this process?
    d. Write the net-ionic reaction for this process.

    e. What is the limiting reactant? ***Hint:*** *ion?*

    f. How many moles of the solid precipitate are formed Assume 100% yield? What is the mass of this precipitate?

g. What reactant, if any, is in excess, and how many moles are there in excess?

h. What are the final concentrations (M) for each of the ions **in solution** after precipitation? Assume that the final volume of the solution is 600 mL.

Starting Ions	Number of moles of ions still in the solution	Concentration of Ions in the solution: [Ion] $= \frac{n\ (\text{mol})}{V_{new}\ (\text{L})}$

i. Show that final solution electrically neutral by calculating that it contains as many moles of positive charge as it does negative charge.

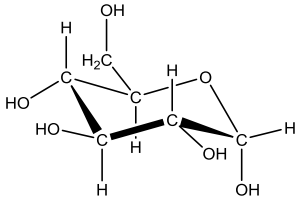
7. What is present in the solution when the following compounds are placed in water?
Note water above the arrows. Is that water necessary? What should you use in the balanced chemical reaction to indicate that water is a solvent not a reactant?

a. $Ba(OH)_2(s) \xrightarrow{H_2O}$

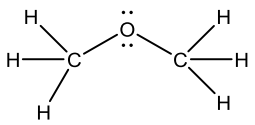
b. $(NH_4)_3PO_4(s) \longrightarrow$

c. $Ni_2O_3(s) \longrightarrow$

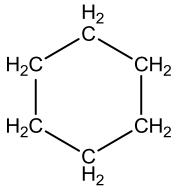
d. $C_6H_{12}O_6\,(s) \longrightarrow$



e. $CH_3OCH_3\,(l) \longrightarrow$



f. C_6H_{12} (l) ⟶



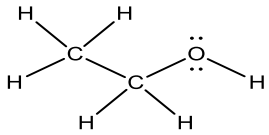
g. $Na_3PO_4(s) + BaCl_2(s)$ ⟶

h. $Fe(OH)_2(s)$ ⟶

i. $K_3PO_4(s)$ ⟶

j. $BaS(s)$ ⟶

k. C_2H_5OH (l) ⟶



8. Predict the relative water solubility (from most soluble to least soluble) for the following molecules. Remember to consider both the polar and non-polar parts of the molecule.

   a. $CH_3CH_2CH_2CH_2OH$
   b. $CH_3CH_2CH_2CH_2CH_2OH$
   c. $HOCH_2CH_2CH_2CH_2OH$
   d. $HOCH_2CH_2CH_2OH$

   Which one has the highest dispersion force? Does dispersion force contribute to solubility in water?

9. If 80. grams of calcium chloride are dissolved in 500. mL of water, what will be the molarity of calcium ion. If I then add an additional 500. mL of water, what would be the new molarity of calcium ion?

10. How many grams of $CaCl_2$ (s) has to be added to 1.00 L of water to get 0.0400 M solution of Cl^- (aq)?

11. To analyze the alcohol content of a certain wine, a chemist needs 1.00 L of an aqueous 0.200 M $K_2Cr_2O_7$ (294 g/mol) solution. How much solid $K_2Cr_2O_7$ must be weighed out to make this solution?

12. An average human has about 5.0 L of blood in their body. If an average person were to eat 34.2 g of sugar ($C_{12}H_{22}O_{11}$; 342 g/mol) and all the sugar dissolves into the bloodstream, what would the person's blood sugar be in units of molarity?

13. If you take 3.00 moles of potassium sulfate and added to one liter of water. If we then take a cubical sample of 1000. water molecules of that solution, how many ions of potassium will be in that cube? How many sulfate ions will be in that cube? How many of both ions will be in that cube?

14. A standard solution is prepared for the analysis of fluoxymesterone ($C_{20}H_{29}FO_3$; 336 g/mol), an anabolic steroid. A stock solution is first prepared by dissolving 16.8 mg of fluoxymesterone in enough water to give a total volume of 500.0 mL. A 1.0 μL aliquot (portion) of this stock solution is taken out and then diluted to a final volume of 1.0 mL. Calculate the final concentration of this new solution in M.

15. You are given 150. mL of a 0.20 M aqueous solution of ammonium carbonate and 150 mL of 0.40 M aqueous solution of barium iodide. These solutions are mixed and a precipitate forms.
    a. Write the net-ionic equation for this process.
    b. In terms of the net-ionic equation, what is the limiting reactant?
    c. How many moles of the solid precipitate are formed?
    d. What are the spectator ions for this process?
    e. What are the final concentrations (M) for each of the ions in solution after precipitation?
    f. Show that final solution electrically neutral by calculating that it contains as many moles of positive charge as it does negative charge.
16. How would you check the presence of Ag^+ ions in a liquid sample with a chemical you always have in your kitchen?

17. How would you check the presence of Pb^{2+} ions in a liquid sample with a chemical you always have in your kitchen?

18. Write the net ionic reaction when $Pb^{2+}(aq)$ reacts with the yellow transparent solution of $CrO_4^{2-}(aq)$.

Solubility Rules

Mahaffy, 2e Figure 6.28 page 181 (memorize)

When determining if an ionic compound will be soluble in water, break it into its ions. Read the rules in numerical order. As soon as your ions meet a criterion, stop reading the chart and use that rule. For example, $(NH_4)_3PO_4$ is soluble. Rule #1 supersedes Rule #7.

Soluble:

1. Group 1 and NH_4^+ compounds
2. Acetate (CH_3COO^-), Nitrate (NO_3^-), Perchlorate (ClO_4^-), Chlorate(ClO_3^-)
3. Halide compounds (Cl^-, Br^-, I^-) [Except: Ag^+, Pb^{2+}, Hg_2^{2+}]
4. Compound containing F^-. [Except: Mg^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}]
5. Sulfate compounds (SO_4^{2-}) [Except: Pb^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}]

Insoluble:

6. Sulfide compounds (S^{2-})
7. Carbonate(CO_3^{2-}) compounds
8. Oxalate($C_2O_4^{2-}$) compounds
9. Phosphate(PO_4^{3-}) compounds
10. Chromate(CrO_4^{2-}) compounds
11. Most metal Oxides
12. Metal Hydroxide compounds (OH^-) [Except: Ba^{2+}]

Numerical Answers:

1. 4.0 mol H-bonds
   a. 0
2.
   a. 26 kJ/mol (At home: 4.4×10^{-23} kJ/H-bond)
   b. 42 kJ/mol H_2O
3. Al, CH_3OH, NI_3
4. 55.6 M
5. 3 M
6.
   a. $Ca^{2+} = 0.06$ mol; $Cl^- = 0.12$ mol; $Na^+ = 0.18$ mol; $PO_4^{3-} = 0.06$ mol
   b. $Ca^{2+}(aq)$, $Cl^-(aq)$, $Na^+(aq)$, $PO_4^{3-}(aq)$
   c. $Na^+(aq)$, $Cl^-(aq)$
   d. $3\ Ca^{2+}(aq) + 2\ PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$
   e. $Ca^{2+}(aq)$
   f. 0.02 moles $Ca_3(PO_4)_2$; 6.2 g $Ca_3(PO_4)_2$
   g. 0.02 moles excess $PO_4^{3-}(aq)$
   h. 0.0 M Ca^{2+}; 0.2 M Cl^-; 0.3 M Na^+; 0.03 M PO_4^{3-}
   i. Positive = 0.18 mol; Negative = 0.18 mol; Net = 0.0 charge
7.
   a. $Ba^{2+}(aq) + 2\ OH^-(aq)$
   b. $3\ NH4^+(aq) + PO4^{3-}(aq)$
   c. Not soluble
   d. $C_6H_{12}O_6$, soluble
   e. CH_3OCH_3, soluble
   f. Not soluble, 2 immiscible layers
   g. $Ba_3(PO_4)_2(s)$
   h. $Fe(OH)_2$
   i. $3\ K^+\ (aq) + PO4^{3-}\ (aq)$
   j. BaS(s)
   k. $C_2H_5OH(aq)$, soluble
8. Solubility: d,c,a,b; Dispersion force: b or c
9. 1.4 M, 0.72 M
10. 2.22 g $CaCl_2$
11. 58.8 g $K_2Cr_2O_7$
12. 2.0×10^{-2}M
13. 108 K^+ ions, 54.0 SO_4^{2-} ions, 162 total ions
14. 4.0×10^{-7} M
15.
   a. $CO_3^{2-}(aq) + Ba^{2+}(aq) \rightarrow BaCO_3(s)$
   b. CO_3^{2-} is limiting
   c. 0.03 mol $BaCO_3$
   d. $NH_4^+(aq)$, $I^-(aq)$
   e. 0.00 M CO_3^{2-}, 0.10 M Ba^{2+}, 0.20 M NH_4^+, 0.40 M I^-
   f. Positive = 0.12 mol; Negative = 0.12 mol; Net = 0.0 charge