Chem 151 Drilling Question Set #3
Solubility of Inorganic Compounds

Basically, all substances are soluble in water, but, in different extents. Some are very soluble (and hence are classified as soluble compounds); some dissolves only to a very small extent and are considered as "insoluble". Those with solubilities in between are classified as "slightly soluble" or "moderately soluble". When an ionic compound dissolves in water, it dissociates into the substituent cations and anions, making the solution a good conductor of electricity. Ionic compounds are strong electrolytes. When covalent compounds dissolve in water, some remain as a solvated molecule making the solution a non-conductor of electricity; some mostly remain as solvated molecules but dissociate in a small extent making the solution a weak conductor of electricity. Usually, covalent compounds (and polar covalent compounds) are non-electrolytes and weak electrolytes. Experiments 1 and 2 have discussion on the dissolution of ionic compounds and covalent compounds in water. Listed below is the Table of Solubility Guidelines from Experiment 2.

Table 1. Solubility Guidelines

1. **The nitrates, chlorates, and acetates of all metals are soluble in water.** Silver acetate is slightly soluble.

2. **All sodium, potassium and ammonium salts are soluble in water**. In general, alkaline metal salts are soluble in water.

3. **The chlorides, bromides, and iodides of all metals except lead, silver, and mercury are soluble in water.** The heavy metal halides (e.g., lead bromide and silver chloride) are insoluble. $PbCl_2$, $PbBr_2$, and PbI_2 are insoluble in cold water but moderately soluble in hot water.

4. **The sulfates of all metals except lead, mercury(I), and barium are soluble in water.** Silver sulfate, calcium sulfate, and strontium sulfate are slightly soluble.

5. **The carbonates, phosphates, sulfites, sulfides, borates, and arsenates of all metals except alkali metals and ammonium are insoluble in water but soluble in dilute acids**. $MgSO_3$ and Li_2CO_3 are slightly soluble.

6. The hydroxides of alkali metals are very soluble in water. The hydroxides of calcium and barium are moderately soluble. **The oxides and hydroxides of all other metals are insoluble in water but soluble in acids.**

1. Based on the solubility guidelines to predict whether each of the following compounds is likely to be classified as water soluble or insoluble. Circle your responses)

   $MgCO_3$ (Soluble / Insoluble)

   $NiBr_2$ (Soluble / Insoluble)

   $ZnSO_4$ (Soluble / Insoluble)

   Al_2O_3 (Soluble / Insoluble)

   $Pd(NO_3)_2$ (Soluble / Insoluble)

   CoI_2 (Soluble / Insoluble)

   $CaSO_3$ (Soluble / Insoluble)

   Rb_3PO_4 (Soluble / Insoluble)

2. List the formula(s) of the major species (cations, anions, or molecules) in water when each of the following substances dissolves in water.

   Potassium sulfide

   Ferrous sulfate

   Hydrofluoric acid (a weak electrolyte)

   Copper(II) chlorate

   Lead(II) acetate

   Cesium oxalate

   Oxygen gas

3. When solutions in each of the following mix with each other, predict if precipitate is likely to form. If your prediction is YES, give the chemical formula of the precipitate.

   Sodium chloride solution is added to lead(II) nitrate solution (YES / NO)

   Nickel sulfate solution is added to barium chloride solution (YES / NO)

   Potassium phosphate solution is added to manganese(II) chloride solution (YES / NO)

   Copper(II) chloride solution is added to cobalt(II) sulfate solution (YES / NO)

   Lithium sulfate solution is added to sodium hydroxide solution (YES / NO)

   Hydrobromic acid is added to lead(II) nitrate solution (YES / NO)

   Phosphoric acid is added to rubidium chloride solution (YES / NO)

4. Listed below are solubilities of some lead compounds in grams per liter of water. Calculate the molarity of Pb^{2+} ions in a solution that is saturated with each of the compounds. Solubility of a substance is the quantity of this substance that can dissolve in a given amount of solvent. For the sake of simplicity, you may assume the volume of solvent and volume of solution are the same in the below calculations. This in general, is a good assumption for very dilute solutions, but not true when the concentration becomes high.

   a) PbS: 0.00086 g/L

   b) $PbCl_2$: 33.4 g/L in hot water

   c) $Pb(NO_3)_3$: 376 g/L