

# Solubility, Kidney Stones, and CSI

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## Introduction:

Solubility of ionic compounds (salts) depends on the solute-solute vs. solute-solvent interactions. If the solute-solvent interactions are stronger than the solute-solute interactions, the salt will be soluble in that solvent. Conversely, if the solute-solute interactions are too strong to be overcome by the solute-solvent interactions, the salt will be insoluble in that solvent. Going more in depth, we find that all ionic compounds will dissolve to a certain degree in water. In the case where the salt is considered insoluble macroscopically, on the molecular level a tiny fraction of ions dissolve to give a saturated solution. The amount of ions dissolved is so small that, for all practical purposes, we consider that salt to be insoluble. Conversely, if a salt is deemed soluble macroscopically, very large number of ions dissolve before the solution reaches saturation.

The concept of solubility is experienced in many venues of our lives. "Hard water" is a case where there are certain ions in tap water that precipitate out and cause rings to form around bathtubs, sinks and fixtures. A biological example of this same phenomenon is kidney stones. In many areas of the world kidney stones are a terrible problem and their treatment is not well understood. Kidney stones usually form when ions react to form an insoluble precipitate. The most common type of kidney stone is composed of an inorganic salt of calcium or other multivalent cation with oxalate or phosphate, sometimes complexed in an organic matrix. People who are prone to kidney stones usually have to limit or avoid eating foods with high oxalate content. Such foods include spinach, beets, wheat germ, peanuts, okra, chocolate, black tea, and sweet potatoes. A non-invasive approach to treating kidney stones is to drink a large amount of water in order to flush the stones out of the urinary tract.

## The Problem:

Over the next two weeks, you will be experimenting with cation solubility of inorganic compounds. With the gained information from the known tests you conduct in week one, you will have to identify the cations present in an unknown solution in week two.

## Prelab Questions:

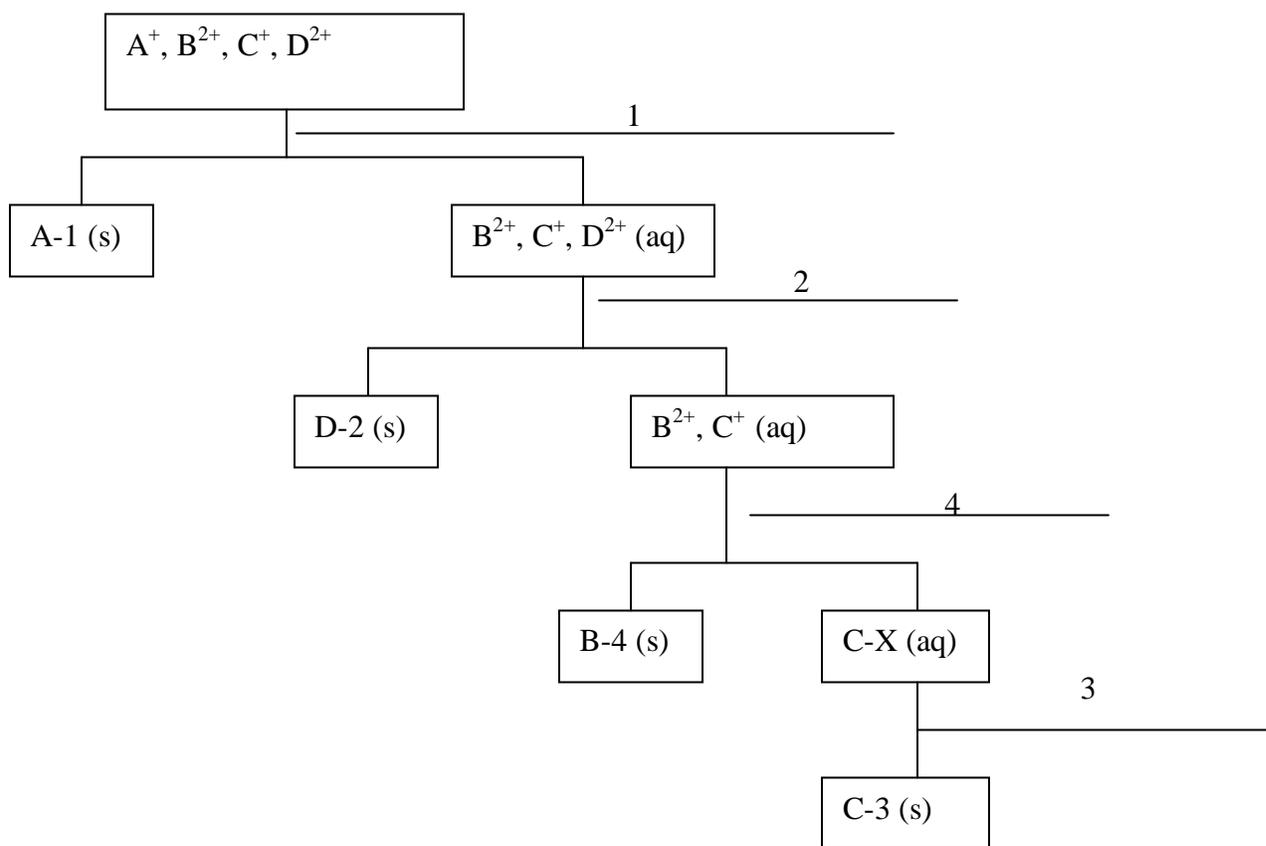
Following are some questions to consider before starting week 1 of the lab.

- Are there any patterns in the cation solubility listed in your textbook?
- Why is it that some combinations of ions do not seem to react while others result in a precipitate?
- For an insoluble compound, how might you prevent formation of the precipitate?
- What conditions can you manipulate to make the precipitate more soluble?
- Does the size of the crystal affect the solubilization process?
- How do you accurately rule out the presence of alkali metals in a solution?
- Which combinations of ions used do you expect to form insoluble salts? What are their  $K_{sp}$  values?

**Week 1:**

Determine which combinations of common reagents containing cations (sodium, potassium, calcium, magnesium, copper, iron, nickel and silver) and anions (chloride, sulfate, nitrate, oxalate, phosphate, hydroxide, etc.) will most likely result in insoluble salts. Devise a flow chart showing the series of reagents to be added to a mixture containing multiple cations and/or anions in order to best identify all the ions present in solution.

Below is a sample flow chart for four cations,  $A^+$ ,  $B^{2+}$ ,  $C^+$ ,  $D^{2+}$ , using four anionic reagents, 1, 2, 3, and 4.



**Week 2:**

You will be given an unknown solution containing multiple ions. Use the flow chart you devised from Week 1 to determine the ions present in your unknown solution.

**Critical Data/Discussion to Include in Your Lab Report:**

*NOTE: You will turn in one report for weeks 1 and 2.*

- Flow chart
- All data collected in both weeks
- Chemical reaction(s) possible
- Answer all questions posed above
- Works cited