Lesson Plans for *Salts and Solubility* 2*:* Introduction to solubility
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Background: I teach a dual credit chemistry course using Chemistry 6th Edition Zumdahl Houghton Mifflin, NY, 2003. The students in my class are taking their first high school chemistry course and receive credit for the first semester of college chemistry and credit for the corresponding lab. I have written a series of five activities using the *Soluble Salts* simulation to be used throughout the year. This is the second activity in the series. I plan to use this in the second unit as part of the Composition of Solution (section 4.3).

***Soluble Salts* Introduction:** I didn't need to show how to use the simulation, except to mention that when there are an abundance of particles that the processing can make equilibrium a long time to achieve or freeze our computers. As part of this acitivity, I'll discuss the role of water and why it is not seen in the simulation.

Helpful simulation notes:

- Tl_2S has such a small solubility (8/4) that the number of dissolved particles varies significantly so it would not be a good one to use for calculating K_{sp}.
- Notice that the volume is much smaller for NaCl

Learning Goals: Students will be able to:

- Write the dissolving reaction for salts
- Describe a saturated solution microscopically and macroscopically with supporting illustrations
- Calculate solubility in grams/100ml
- Distinguish between soluble salts and slightly soluble salts macroscopically.

Before the activity:

1. Explain the hydration process. On page 135, there is a good picture. Project *Soluble Salts* and have a class discussion about why the water molecules are not included in the simulation.
2. On the board, demonstrate how the dissolving process is written as a balanced reaction. $HCl_{(s)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$ and $MgCl_2$. Emphasize that the ionic charge must be given for the aqueous ions.
3. Review how to change atoms to grams and L to ml.

During the activity:

In step 2: The students are asked to explain how they know that a solution is saturated to me. The first time I used the sim, a common misconception was that if there are no changes occurring that the solution is saturated. This misconception meant that several students were doing calculations for solubility and K_{sp} when the solution was actually unsaturated.

For step 3: To calculate the solubility, use the number of molecules of the dissolved ions in a saturated solution, then think about the stoichiometry to determine the number of molecules of the salt that dissociated. Then convert to molecules to moles, then moles to grams and divide by liters, then make a ratio to change the volume to 100ml. The order that students do the conversions doesn't matter. For example the calculation for NaCl (180 Na ions dissociate in

5E-23L) might look like: (180molecules/6.02E23molecules/mole)*(58.5grams/mole)/(5E-23L)*.1=35g/100ml

Post-lesson: use the clicker questions

Post activity class discussion questions:

1. Have the students read the final paragraph on p151 where the solubility rules are introduced. Talk about what is meant by soluble, slightly soluble and insoluble.

   The solubility rules in our text: Alkali metals salts, ammonium salts and nitrates are soluble. Halides are soluble except silver, mercury and lead. Sulfates are soluble except silver, mercury and lead and large alkali earth metals. All other salts are insoluble. (There are many versions of the rules; this is what we use).

2. Write the seven compounds in words used in the sim on the board and have the students use the solubility rules to predict which of the salts would be soluble based on the rules. (The compounds are: NaCl, AgBr, Tl_2S, Ag_3AsO_4, CuI, $HgBr_2$, $Sr_3(PO_4)_2$)

3. As a class, have a discussion that provides a "rule" to explain what "soluble" means in terms of g/ 100ml. *(Our book does not give a general rule for "soluble" in quantitative terms. The high school book that we use in regular chemistry class (Chemistry published by Merrill in 1994) has 3 g in 100ml.)* I expect them to be able to see that the magnitude of g/ml of the slightly soluble is quite small compared to that for NaCl.

Useful information:

Compound	K_{sp} expression (x is moles/l dissociated)	Molar mass	Common information			From sim	
			Solubility in moles/L	K_{sp}	Solubility in g/100ml	# Cations at saturation	# Anions at saturation
NaCl	x^2	58.5	6.0	36	35	180	180
AgBr	x^2	188	7.3E-7	5.3 E-13	1.4E-5	45	45
Tl_2S	$(2x)^2x$	441	5.3E-8	6 E-22	2.3E-6	8	4
Ag_3AsO_4	$(3x)^3x$	463	1.4E-6	1.0 E-22	6.4E-5	255	80
CuI	x^2	190	1.0E-6	1.1E-12	1.9E-6	64	64
$HgBr_2$	$x(2x)^2$	361	2.5E-7	6.2E-20	9E-6	16	32
$Sr_3(PO_4)_2$	$(3x)^3(2x)^2$	452.8	2.5E-7	1E-31	1.1E-5	45	30