Name: ________________________ Date: ________________________

Virtual Lab: Solubility Product Constant

We have already learned that there exists an equilibrium constant, $K_{eq,}$ for any system in equilibrium. So far, we have only explored this as $K_{c,}$ which is calculated using concentrations of products and reactants of any given system at equilibrium. Depending on the type of system under investigation, K_{eq} can be calculated using other measurements.

K_{sp} is the solubility product constant, and it is defined as the maximum amount of ions that can be dissolved at a given temperature. A saturated solution is in a state of dynamic equilibrium between the dissolved, dissociated, ionic compound and the undissolved solid. As with K_c, the solid reactant is never included when calculating the value of K_{sp}.

The general formula for calculating K_{sp} for the given equation: $M_xA_{y(s)}$ --> x $M^{y+}_{(aq)}$ + y $A^{x-}_{(aq)}$,

$$K_{sp} = [M^{y+}]^x[A^{x-}]^y$$

Ex: $PbCl_{2(s)} \leftrightarrows Pb^{2+}_{(aq)} + 2\ Cl^{-}_{(aq)}$

$$K_{sp} = [Pb^{2+}]\ [Cl^{-}]^2$$

In order to familiarize yourselves with this solubility product constant, you will complete a dry lab. Follow the procedure below and answer all questions that follow.

Procedure:

1. Go to http://phet.colorado.edu/en/simulation/soluble-salts and download the *Salts and Solubilities* applet.
2. Click on the *Table Salt* tab.
3. Shake on the salt shaker to add salt to the water until the solution reaches a point of saturation (i.e. the *Bound* values should both be 0, but one more shake would result in a non-zero value). **Do not adjust the volume.**
4. Record these values in Table 1.
5. Calculate the number of mols of each ion, the concentration of each ion, and the value of K_{sp}.
6. Click on the *Slightly Soluble Salts* tab.
7. Repeat steps 3 – 5 for each of the salts listed in Table 1.

Salt	# of cations at saturation	# of mols of cation at saturation	[cation] at saturation	# of anions at saturation	# of mols of anion at saturation	[anion] at saturation	K_{sp}
Table Salt							
Mercury (II) Bromide							
Silver Bromide							
Copper (I) Iodide							
Strontium Phosphate							
Thallium Sulfide							
Silver Arsenate							

Analysis:

1. What is the chemical name for table salt?

2. Write the chemical formula for each of the salts above just below its corresponding name.

3. Which salt had the highest K_{sp} value?

4. Which salt had the lowest K_{sp} value?

5. What does a high K_{sp} value mean about the dissolution of a salt?

6. How does the speed at which you add the salt effect the equilibrium?

7. Define *saturation*.

For a given reaction

$$aA + bB \leftrightarrow cC + dD$$

Q, the reaction quotient, is calculated using:

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

You will notice that this is the same formula to calculate K_{eq}. However, the reaction quotient can be calculated at any point in a reaction – **not only when it is at equilibrium**. Comparing its value to the equilibrium constant, K_{eq}, can give us information about what is happening in the system.

- At equilibrium, $Q = K_{eq}$
- If Q > K, the reverse reaction is favoured, the reaction moves from right to left, until equilibrium is established.
- If Q < K, the forward reaction is favoured, the reaction moves from left to right, until equilibrium is established.

When working with $K_{sp,}$ equilibrium is established when a solution is saturated.

- When Q = Ksp, no precipitate will form and a saturated solution exists.
- When $Q > K_{sp}$, a precipitate forms and a saturated solution exists.
- When Q < Ksp, a precipitate will not form.

8. What is a precipitate? Draw a diagram to support your answer.

9. A reaction quotient, Q, is calculated for the dissolution of table salt. If Q = 22, will a precipitate form? If Q = 42, will a precipitate form? Explain your answers.