



Name: \_\_\_\_\_

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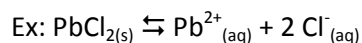
## Virtual Lab: Solubility Product Constant

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:  $M_xA_{y(s)} \rightleftharpoons x M^{y+}_{(aq)} + y A^{x-}_{(aq)}$ ,

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



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

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



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  $Q = K_{sp}$ , no precipitate will form and a saturated solution exists.
- When  $Q > K_{sp}$ , a precipitate forms and a saturated solution exists.
- When  $Q < K_{sp}$ , 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.