Experiment # 10: Solubility Product Determination

When a chemical species is classified as "insoluble", this does not mean that none of the compound dissolves in the given solvent or solution system. In reality, a measurable level of material does go into solution, but it is sometimes considered negligible relative to the total amount of the chemical. perhaps a better name for such salts is "sparingly soluble." The dissolving of a solid monovalent-monovalent salt, represented as MX, in an appropriate solvent is represented by the general equation:

$$MX_{(s)} \rightleftharpoons M^{+}_{(aq)} + X^{-}_{(aq)}.$$

where the subscripts "(s)" and "(aq)" represent the solid and aqueous solution physical states, respectively. For a set of given conditions, the precipitate has a definite solubility (or maximum amount that will dissolve) expressed in units of grams/liter or moles/liter.

An equilibrium constant expression can be written for the above reaction, as: $K_{eq} = [M^+][X^-]/[MX]$. The "concentration" of any solid material, such as MX, is proportional to its density and is constant. Thus, the term [MX] is usually combined into the K_{eq} value, giving: K_{eq} [MX] = [M^+

In this experiment, the relative solubility (and an approximate value of the K_{sp}) of lead iodide will be determined by direct observation. The procedure calls for the mixing of two standard solutions (one of a soluble lead salt, and a second of a soluble iodide salt) in different proportions and allowing time for the resulting mixture to come to equilibrium. In some of the mixtures, the solubility product constant for lead iodide will be exceeded, and precipitation of PbI_2 crystals will occur. In other mixtures, the final concentrations of lead and iodide ions will be such that precipitation does not occur.

After preparing the solutions, allow each mixture to set for at least 30 minutes before checking for precipitation. During this equilibration period, calculate the theoretical or maximum concentration of each ion in the mixture, using the equation:

$$[\text{Ion}]_{\text{mixture}} = [\text{Ion}]_{\text{standard}} \times \frac{\text{mL's ion in solution}}{\text{mL's total mixture}}$$

Use these concentration values to calculate the “Q” value for each mixture, and record the data in Table I. Colorless clarity (clearness) of solution indicates no precipitate. Golden cloudiness (lack of clarity) indicates formation of a precipitate.

After the equilibration period is completed record under the “PbI_2?” column whether or not a precipitate has formed in each test tube. If all goes well, the mixtures of higher Q values will contain shiny, golden crystals of lead i7af3ek of