Demonstration: Precipitation Reaction

FOR THE TEACHER

Summary
In this demonstration, students will observe a precipitation reaction. Students will create several particle diagrams in order to describe and fully understand what is occurring on the atomic level during the chemical reaction.

Grade Level
High School

Objectives
By the end of this demonstration, students should be able to
- Indicate that a precipitate can form from the reaction of two aqueous solutions.
- Understand the components described by a net ionic equation.
- Create particle diagrams for solutions containing dissociated ions.
- Apply their knowledge of solubility rules to the outcome of a chemical reaction.
- Write a chemical equation for a reaction that produces a precipitate.
- Draw accurate particle diagrams for reactions that include aqueous species and formed precipitates.

Chemistry Topics
This demonstration supports students' understanding of
- Chemical Reactions
- Classification of Reactions
- Indicators of Chemical Change
- Net Ionic Equations
- Solubility Rules
- Particle Diagrams

Time
**Teacher Preparation:** 5 minutes
**Lesson:** 40-50 minutes

Materials
- ~5ml of 0.1 M Potassium Iodide
- ~ 1ml of 0.1 M lead(II) nitrate in a dropper bottle
- Test tube
- Test tube rack

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash hands thoroughly before leaving the lab.
- Students should wear proper safety gear during chemistry demonstrations. Safety goggles and lab apron are required.

Teacher Notes
- In this demonstration PbI₂(s) is produced from aqueous solutions of Pb(NO₃)₂ and KI:
  \[ \text{Pb(NO}_3\text{)}_2(aq) + 2\text{KI}(aq) \rightarrow \text{PbI}_2(s) + 2\text{KNO}_3(aq) \]
It is important that teachers remind their students that this reaction uses aqueous solutions, which do not contain discrete molecules, but rather dissociated ions. Many students struggle with understanding that $\text{KNO}_3(aq)$ actually represents $\text{K}^+(aq) + \text{NO}_3^-(aq)$. The reaction is more accurately represented with an ionic equation:

$$\text{Pb}^{2+}(aq) + 2\text{NO}_3^-(aq) \rightarrow \text{PbI}_2(s) + 2\text{K}^+(aq) + 2\text{NO}_3^-(aq)$$

Customarily we do not include non-reacting species (i.e. spectator ions), which when removed clearly show that the reaction is a precipitation reaction:

$$\text{Pb}^{2+}(aq) + 2\text{I}^-(aq) \rightarrow \text{PbI}_2(s)$$

Demonstration Procedure (video of demo is included):

1. Fill a test tube $\frac{1}{4}$ of the way with 0.1 M potassium iodide.
2. Add one drop of 0.1 M lead(II) nitrate. A bright yellow precipitate of lead(II) iodide forms immediately.
3. Let it sit for the remainder of class so students can observe the solid settling to the bottom (some don’t think a solid has formed in the initial suspension).

Performing the reaction in a test tube as a small-scale demonstration minimizes the amount of the lead-containing product to be disposed. It can definitely be scaled up to serve as quite a beautiful demonstration, you just have to filter and dispose of the lead(II) iodide appropriately.

Before the solutions are mixed, I demonstrate that both reactants conduct electricity using a small conductivity tester. Then, in groups, students draw particle diagrams of each of the solutions on large white boards to review that each solution contains dissociated ions as evidenced by their conductive abilities.

After I mix the solutions, I challenge the student groups to draw a particle diagram of the mixture, identify the yellow solid, and write a chemical reaction that shows the production of the solid. Students were introduced to basic solubility rules for ionic compounds in the previous unit, though I do not remind them of this at first.

After allowing them time to work on their own, we have a class discussion about the reaction and conclude that the yellow precipitate is PbI$_2$(s). I offer the explanation that the solid forms because the ions are more attracted to one another than to the water molecules. Some discussion questions I’ll ask may include:

1. Are all ionic compounds soluble in water? How have we previously determined which are soluble and which are not?
2. What possible ionic compounds could be produced from the species present in the solution?
3. How do we know the formula of the solid is PbI$_2$ instead of PbI or some other ratio of ions?
4. What ions or molecules are present in the solution after the formation of the solid?

- After the discussion, I teach my students the general rules of writing net-ionic, complete ionic, and molecular reaction equations and we discuss the benefits and shortcomings of each.
- My students then do a practice worksheet where they practice the skills in writing equations and drawing particle diagrams that they learned.
- For a complete look in to how this lab fits in to the curriculum of the author, please refer to the associated article, published in the March 2018 issue of Chemistry Solutions.