Lesson Title	A Solution for Precipitation
Length of Lesson	1 hour 15 min
Created By	Chris Ruhs
Subject	Chemistry
Grade Level	10-12th Grade
State Standards	Chemistry I: 6a,c,d; 7a,b,e; 11a,
DOK Level	DOK 2
DOK Application	Students demonstrate their use of knowledge of solubility, ionic compounds, and writing equations.
National Standards	9-12: A (Inquiry); B (Physical Science)
Graduate Research Element	Understanding solubility, solutions, and precipitations is crucial for biogeochemists trying to understand natural systems.

Student Learning Goal:

MS 9-12th Grade:

Chemistry I: 6 (a) Write chemical formulas of ionic compounds using monatomic and polyatomic ions; (c) Write names of compounds from their formulas; (d) Given the formula of a compound, identify oxidation states of the elements. *Students will write chemical formulas of ionic compounds from written names, making sure to balance charges.*

7 (a) Write an equation in sentence form (word equation) when given a chemical equation; (b) Balance a simple chemical equation by inspection when given the formulas or names of all reactants and products; (e) Given a list of solubility rules, predict if a precipitate is formed upon mixing solutions of known chemicals in a double displacement reaction. *Students will write and balance chemical equations that they predict will produce a precipitate by using a list of solubility rules.*

11 (a) Describe solutions in terms of solute and solvent; electrolyte or non-electrolyte; soluble or insoluble; unsaturated, saturated or supersaturated; miscible or immiscible. *Students will discuss solubility, what "dissolving" means, and how ionic compound break into their component ions when they dissolve.*

National Science Education Standards of Content 9-12:

A: Inquiry: Identify questions and concepts that guide scientific inquiry; design and conduct scientific investigations; communicate and defend a scientific argument. *Students will work together to predict whether or not a compound of their choosing will form a precipitate with a compound they were given—they will present this prediction to the class, and then be given the opportunity to demonstrate the actual reaction to test their prediction.*

B: Physical Science: Chemical reactions. *Students will explore and understand the complexities of precipitation reactions, both written and actual.*

Materials Needed (supplies, hand-outs, resources):
Solubility rules table, about 14-20 (depending on class size) pre-made solutions, 7-10 (depending on class size) clean beakers.

Lesson Performance Task/Assessment:
Formative:

1. Hand out a reference sheet, listing the common solubility rules for chemistry; explain how the solubility rules work.
2. Discuss the idea of dissolving; reference sugar and salt in water (which they've all seen before); draw a water molecule and explain it's polar nature; explain how soluble compounds break into the component ions, so that the positive ion "hangs out" with the negative side of water, and the negative ion "hangs out" with the positive side of water.
3. Take several examples of ionic compounds; have the students tell you how to balance the charges for each ionic compound; allow the students to determine whether each compound is soluble or insoluble in water; have them explain why in reference to the solubility rules; remind the students that the compounds will break up into their component ions when they dissolve; let the students name some ionic compounds, and work through them the same way.
4. Once they have are able to fluently balance ionic compound charges, determine the compound's solubility, and understand that if an ionic compound is soluble it will break into component ions, introduce the students to an ionic precipitation reaction. This is achieved by selecting to soluble ionic compounds where the cation of one compound will ionically bond with the anion of the other compound to form an insoluble salt. Use "(aq)" to show that an ion is in solution, and explain that it stands for "aqueous". Write down a chemical equation slowing, showing each ionic compound as separate ions.
    a. For example, the reaction of silver nitrate with sodium hydroxide is as follows:

$Ag^+ (aq) + NO_3^- (aq) + Na^+ (aq) + OH^- (aq) \rightarrow AgOH (s) + Na^+ (aq) + NO_3^- (aq)$

5. Show the students that this equation forms a silver hydroxide precipitate, and that there are the same number of each different atom on both sides of the equation.
6. Bring out two solutions and pour them together to show them an example of a precipitation reaction. Explain that the compounds they are writing on their papers are in the flasks you are holding. Explain that when poured together, some of the ions found each other in solution and "un-dissolved" or more properly "precipitated". Allow for questions.
7. Work through a few more equations with ionic compounds, teaching the students how to balance the equations.

Summative:

1. Put the students in groups of three or four.
2. Assign each group a soluble ionic compound that has a transition metal cation.

3. Allow the students to select from a list of soluble ionic compounds that might react with their assigned compound to produce a precipitation.
4. Each group must work together to pick an appropriate compound to achieve a precipitation reaction; they must write the chemical equation for this reaction correctly and balance it.
5. Once each group has finished this task, have one member from each group present their chemical equation to the class by writing it on the board. The students in the other groups should carefully copy down the chemical equation being presented.
6. Once every group presents, every student should have a list of properly balanced chemical equations that (hopefully) produce a precipitation.
7. It is now time to go to the lab, to see in real life what the equations mean.
8. Having pre-made each solution for the compounds that were assigned and the compounds on the list, allow each group to carefully demonstrate the precipitation reactions by pouring their two soluble compounds together in a beaker, and observing what happens.
9. After each group has demonstrated their reaction, return to the classroom and discuss, review, and close.

Lesson Relevance to Performance Task and Students:
Students will review balancing ionic compound charges. Students will learn how to use solubility rules and what "dissolving" means. Students will learn how to write and balance ionic equations (not net ionic equations yet). Students will see a precipitation reaction and relate it two the chemical equations they write on paper. Students will work in a group to choose their own reaction, and then have the opportunity to demonstrate their choice in the lab.

Anticipatory Set/Capture Interest:
Showing the students the first precipitation reaction will draw them into the material.

Guided Practice:
Students will practice writing ionic compounds and ionic equations as well as understand solubility rules together with the teacher.

Independent Practice:
Students will work in teams to choose from a list a compound that will cause a precipitation reaction with their assigned compound. Students will write the chemical equation for this reaction and present it to the class. Students will demonstrate the chemical reaction that relates to their chosen chemical equation.
Homework: more practice with writing and balancing equations.
Test questions

Remediation and/or Enrichment:
Remediation:

Individual IEP, skip the balancing part for now, focus on relating compounds to real solutions in the lab.

Enrichment: segue into net ionic equations with a discussion on spectator ions.

Check(s) for Understanding:
How do you know if something is soluble?
What does it mean for a compound to dissolve?
What does it mean for a compound to precipitate?

Closure:
A student-lead, teacher-guided summary discussion will bring closure to the lesson plan.

Possible Alternate Subject Integrations:
Biology: talk about how ions in nature travel in water when soluble, but can precipitate out of solution, given the right circumstances. This is important for most biological systems.

Teacher Notes:
Many precipitation reactions will end up with a white crystalline precipitate, which can become very boring and repetitive. Make your compounds produce a variation of colors.