Student’s Lesson at a Glance

Lesson Summary

This lesson contains seven activities, one of which is a wet lab to help students better understand precipitation reactions. Students connect the lesson to real-world examples through a reading that explains how gold is recovered through a series of precipitation reactions. Students are shown static screen shots of an undefined reaction and asked to determine if a chemical reaction occurred. Following the wet lab and a teacher demonstration of the technology and procedures, students will use the simulations to replicate the mixtures created in lab. From the simulations, students create submicroscopic sketches, determine if a chemical reaction occurred, and figure out if a precipitate was formed. The final activity introduces students to net ionic equations. Following a teacher demonstration, students will use static pictures of the simulations to create net ionic equations.

SWBAT (Student will be able to)

- Know that double displacement reactions can produce precipitates
- Know that a precipitate is an insoluble product that results from a chemical reaction
- Know that spectator ions are ionic compounds or ionic elements that remain in solution and do not participate in single displacement or double displacement reactions
- Use submicroscopic chemical representations and chemical symbols to represent chemical reactions observed macroscopically in the laboratory

Essential Vocabulary

Keep a list of all important words from this lesson. This list, in addition to the lists from other lessons, will make studying easier and improve scientific communication skills. The essential vocabulary from the unit is in bold. Additional words that will expand your scientific vocabulary are in italics.
CCC Reminder

- Recall some reactions occur in water; this includes precipitation reactions. An aqueous solution is denoted by the abbreviation \((aq)\) following the name of a chemical species in a reaction. Water acts as the medium for the reaction to occur, but is not included in the chemical formula.

- Use the vocabulary section and note section to take good notes so that studying for tests and quizzes will be easier.

- Supporting claims with evidence is not only a skill that scientists use, but a skill that will help you in other classes and everyday life.

- Draw a key when you are sketching. Symbolic keys can help you and others decode your sketches at a later time. Include ions separately from non-charges atoms when creating the key.

- Ions are charged particles that show up with a grey halo in the simulations. Ions make up ionic compounds. Ions are formed when the dissociate in a solution. Use the periodic table to determine the charge of an ion.

Notes

Homework

Upcoming Quizzes / Tests
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Activity 1: Connecting

When two solutions mix, sometimes a precipitate can form. A precipitate is a solid that forms in a solution during a single replacement or double displacement reaction. The solid that is formed is a new substance. However, not all solutions will generate precipitates.

Companies use many precipitation reactions to remove impurities. For example, gold is refined using precipitation reactions. Gold is among one of the most valuable metals on the planet. It has been valued by humans for thousands of years. This precious metal has been used in jewelry, coins, electronics, and in components for space shuttles. The process of retrieving the precious metal is much more complex and dangerous than just digging in the ground or panning streams to find gold nuggets. Some gold is trapped in quartz, a type of mineral, under the Earth’s crust. Miners dig the quartz out, crush it, then separate the gold from contaminants using heavy machinery and water.

This process produces pure gold and gold sulfides. Further processing yields about 60% pure gold, but some gold is still left as the compound gold sulfide. The miners utilize solubility and precipitation to make sure they get the full monetary benefit. The gold sulfides are ground to a fine powder and dissolved in a solution of cyanide. The gold sulfide dissociates to form an aqueous solution with the cyanide. To recover the gold, zinc dust is sprinkled on the solution, causing a chemical reaction that makes the gold precipitate from the solution.
**Part 1**

1. Can the gold that is directly retrieved out of a mine be classified as a chemically “pure substance”? *Support your claim with evidence.*

2. Early during the processing, pure gold and gold sulfides sink to the bottom of a container full of water. Is this considered a precipitation reaction? *Support your claim with evidence.*

3. What do you think aqueous means?

   The chemical equation that represents how gold is removed from the solution is:

   \[ 2 \text{Au(CN)}_2^- (aq) + \text{Zn} (s) \rightarrow 2 \text{Au} (s) + \text{Zn(CN)}_4^{2-} (aq) \]

4. Classify the above reaction. *Circle one and explain your answer.*

   - Combination
   - Decomposition
   - Single Displacement
   - Double Displacement
   - Combustion

**Part 2**

Gold jewelry is not pure gold; instead the jewelry is a mixture of different metals. The purity of gold in the jewelry is indicated by its *karat number*. For instance, 24K gold is 99.7% gold and the most valuable. In comparison, 10K is only 41.7% gold.

5. Why would mining companies need scientists who understand solubility and precipitation reactions to process the remaining 40% of material after the first stage of mining?

6. What would happen to price of gold if companies settled for retrieving only 60% of what was available in the mined material?
7. Gold mining requires the use of toxic substances which may be made into solutions to help purify gold. What is the potential environmental impact of mining companies who use the procedure described in the paragraph above?

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**Activity 2: Questions to Think About**

*Use the pictures below to answer the questions.*

<table>
<thead>
<tr>
<th>Picture of reaction at submicroscopic level; Before (at time 0 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Picture of reaction at submicroscopic level; After (at time 30 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2.png" alt="" /></td>
</tr>
</tbody>
</table>

**Key**

- **Chloride**
- **Nitrate**
- **Oxygen**
- **Hydrogen**
- **Sodium ion**
- **Silver ion**
8. The reactants for the reaction are AgNO₃ (aq) and NaCl (aq). Why would it be difficult to identify the starting reactants from the pictures alone?

__________________________________________________________________________

__________________________________________________________________________

9. What are the products in the after picture?

__________________________________________________________________________

10. Did a reaction occur between the before and after pictures? *Support your claim with evidence.*

__________________________________________________________________________

11. Write out the chemical equation, including phases, that represents the reaction in the picture.

__________________________________________________________________________

12. In the “after” simulation a precipitate was formed. Identify which product was a precipitate, the state of matter of the precipitate, and what type of reaction occurred.

__________________________________________________________________________

__________________________________________________________________________

Activity 3: Precipitation Wet Lab

This lab will help develop a better understanding of how ionic compounds in aqueous solutions can undergo chemical reactions and form precipitates when they are mixed together. Use the laboratory instructions provided by your teacher.
Use lab results to complete the data table below.

<table>
<thead>
<tr>
<th></th>
<th>KBr</th>
<th>AgNO₃</th>
<th>NH₄Cl</th>
<th>Na₂CO₃</th>
<th>NaOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>LiNO₃</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>KBr</td>
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<td>AgNO₃</td>
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<td>NH₄Cl</td>
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<td>Na₂CO₃</td>
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</tbody>
</table>

Activity 4: Generating Net Ionic Equations

**Part 1:** Read the following introduction as a class.

As you’ve seen in the simulations, ionic compounds are involved in some reactions. Remember that ionic compounds dissociate to form an aqueous solution when placed in water. If an ion is directly involved in the chemical reaction, the ions are always indicated on both sides of the chemical equation. However, if an ion is not directly involved in the reaction, it is called a **spectator ion**. That is, the ion stays in solution and is not part of the precipitate.

Scientists acknowledge all the ions present in a chemical reaction by creating a **complete ionic equation**. This involves writing down all of the aqueous substances as their dissociated ions and keeps all solids, liquids and gases unchanged. Sometimes scientists use a simplified version of the complete ionic equation to emphasize only the ions that participate directly.
in the chemical reaction. This is called a net ionic equation. All spectator ions are removed from the equation and all that remains are the ions that are involved directly in the reaction.

Net ionic equations help scientists understand what is happening during a chemical reaction. You can use a net ionic equation to determine whether a reaction has occurred or not. For example, if you add two aqueous ionic compounds together and a precipitate has not formed, then a reaction has not occurred because all of the ions were spectator ions. You can also use a net ionic equation to determine the identity of a precipitate in the simulations.

Generating Net Ionic Equations is a Three Step Process

Recall the chemical equation (double displacement reaction) for the formation of barium sulfate, a substance used in X-Rays.

\[
\text{BaCl}_2 (aq) + \text{Na}_2\text{SO}_4 (aq) \rightarrow 2 \text{NaCl} (aq) + \text{BaSO}_4 (s)
\]

1. Write the complete ionic equation.

To write a complete ionic equation, rewrite all aqueous substances as their dissociated ions and keep all solid, liquid, and gaseous substances unchanged. You may need to use your periodic table to determine the appropriate charge on the ions.

\[
\text{Ba}^{2+} (aq) + 2 \text{Cl}^- (aq) + 2 \text{Na}^+ (aq) + \text{SO}_4^{2-} (aq) \rightarrow 2 \text{Na}^+ (aq) + 2 \text{Cl}^- (aq) + \text{BaSO}_4 (s)
\]

2. Identify and remove the spectator ions.

Spectator ions are all ions and ionic compounds in the reaction that are identical on both the reactant and product side of the reaction. When you have identified, the spectator ions, remove them from the equation. Remember, water molecules that are present are not included in the equation because water is the solvent.

\[
\text{Ba}^{2+} (aq) + 2 \text{Cl}^-(aq) + 2 \text{Na}^+(aq) + \text{SO}_4^{2-}(aq) \rightarrow 2 \text{Na}^+(aq) + 2 \text{Cl}^-(aq) + \text{BaSO}_4 (s)
\]

3. Write out net ionic equation.

Write the net ionic equation by rewriting the reaction equation, including only those reactants and products directly involved in the reaction. Notice that the final product is a solid; this solid is called the precipitate.

\[
\text{Ba}^{2+} (aq) + \text{SO}_4^{2-} (aq) \rightarrow \text{BaSO}_4 (s)
\]

Always check to see that your net ionic equation is balanced.
Part 2 - Demonstration

With your teacher, you will look at static shots of the reaction provided and create a balanced net ionic equation for the reaction.

1. Write the net ionic equation.

2. What are the spectator ions in this reaction? Support your claim with evidence.

3. Which ions precipitated out, if any? Support your claim with evidence.

4. Is water a spectator ion? Please explain.
Activity 5: Generating Net Ionic Equations

Using the reaction provided in this activity, create a balanced net ionic equation for the reaction.

5. Write the net ionic equation.

6. What are the spectator ions in this reaction? **Support your claim with evidence.**

7. Which ions precipitated out, if any? **Support your claim with evidence.**

8. Is water a spectator ion? **Please explain.**
Activity 6: Lab Demonstration

In this simulation activity, your teacher will first demonstrate how to mix two different ionic compounds together in water. You will observe how these ionic compounds interact submicroscopically. You will complete the remaining simulations in small groups independently. If you completed the wet lab, these simulations will allow you to see the reactions submicroscopically. As you combine different compounds, select substances that have different cations and anions. For example, do not mix AgNO₃ with LiNO₃ because they both contain the NO₃⁻ anion.

Demonstration 1: Use Simulation 2, Set 1

\[ \text{AgNO}_3(\text{aq}) + \text{KBr}(\text{aq}) \rightarrow ? \]

9. Predict the products in the above reaction.

10. After you complete the simulation, did you observe a reaction occurring? Support your claim with evidence.

                        Yes               No

11. Did a precipitate form?

                        Yes               No

12. How are you able to tell whether a precipitate formed or not?

13. If a precipitate formed, what was it?
<table>
<thead>
<tr>
<th>Sketch reaction at submicroscopic level, Before (at time 0 seconds)</th>
<th>Sketch of reaction at submicroscopic level; After (at time 30 seconds)</th>
</tr>
</thead>
</table>

**Key**

<table>
<thead>
<tr>
<th>Complete Ionic Equation Before</th>
<th>Complete Ionic Equation After</th>
</tr>
</thead>
<tbody>
<tr>
<td>→</td>
<td></td>
</tr>
</tbody>
</table>

**Net Ionic Equation**

**Observations**
Demonstration 2: Use Simulation 2, Set 1

\[ \text{LiNO}_3 \text{(aq)} + \text{KBr} \text{(aq)} \rightarrow ? \]

14. Predict the products in the above reaction.

15. After you complete the simulation, did you observe a reaction occurring? **Support your claim with evidence.**

   Yes  No

16. Did a precipitate form?  

   Yes  No

17. How are you able to tell whether a precipitate formed or not?

18. If a precipitate formed, what was it?
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</tbody>
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<table>
<thead>
<tr>
<th>complete ionic equation before</th>
<th>complete ionic equation after</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tr>
</tbody>
</table>

**Net Ionic Equation**

**Observations**
Activity 7: Lab Simulation

Following your teacher’s instruction, create three different mixtures using the simulation and record your observations about each below.

**Part 1: Use Simulation 2, Set 1**

<table>
<thead>
<tr>
<th>Sketch reaction at submicroscopic level, Before (at time 0 seconds)</th>
<th>Sketch of reaction at submicroscopic level; After (at time 30 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Key</th>
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</table>

<table>
<thead>
<tr>
<th>Total ionic equation before</th>
<th>→</th>
<th>Total ionic equation after</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Net Ionic Equation

Observations
19. Did a reaction occur? **Support your claim with evidence.**
   
   Yes               No

20. Did a precipitate form?  
   Yes               No

21. How are you able to tell whether a precipitate formed or not?

22. If a precipitate formed, what was it?
**Part 2: Use Simulation 2, Set 1**

<table>
<thead>
<tr>
<th>Sketch reaction at submicroscopic level, Before (at time 0 seconds)</th>
<th>Sketch of reaction at submicroscopic level; After (at time 30 seconds)</th>
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</thead>
</table>

**Key**

<table>
<thead>
<tr>
<th>complete ionic equation before</th>
<th>complete ionic equation after</th>
</tr>
</thead>
</table>

**Net Ionic Equation**

**Observations**
23. Did a reaction occur? *Support your claim with evidence.*

   Yes               No

________________________________________________________________________

24. Did a precipitate form?               Yes               No

________________________________________________________________________

25. How are you able to tell whether a precipitate formed or not?

________________________________________________________________________

26. If a precipitate formed, what was it?

________________________________________________________________________
### Part 3: Use Simulation 2, Set 1

<table>
<thead>
<tr>
<th>Sketch reaction at submicroscopic level, Before (at time 0 seconds)</th>
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<td></td>
<td>$\rightarrow$</td>
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</tbody>
</table>

**Net Ionic Equation**

**Observations**
27. Did a reaction occur? *Support your claim with evidence.*

   Yes       No

28. Did a precipitate form?        Yes       No

29. How are you able to tell whether a precipitate formed or not?

30. If a precipitate formed, what was it?

**Lesson Reflection Questions**

31. Given the following complete ionic equation, explain what you think would remain in the beaker if the water were evaporated. *Explain your reasoning.*

   \[ \text{Li}^+(aq) + \text{NO}_3^-(aq) + \text{K}^+(aq) + \text{Br}^-(aq) \rightarrow \text{Li}^+(aq) + \text{NO}_3^-(aq) + \text{K}^+(aq) + \text{Br}^-(aq) \]

32. Which reaction type do you think is represented in the precipitation simulations? *Support your claim with evidence.*

**Activity 8: Capstone**

*Use what you have learned to interpret the information, draw a submicroscopic picture of the reaction at time at 0 seconds and 30 seconds that communicates the Law of Conservation of Mass, balance the equation, write a complete ionic equation if appropriate, write a net ionic equation, determine the reaction type, determine the states of matter for the products, and answer the question provided.*

   \[ \text{AgNO}_3(aq) + \text{K}_2\text{CrO}_4(aq) \rightarrow \text{Ag}_2\text{CrO}_4(?) + \text{KNO}_3(?) \]
### Ion Solubility in Water Exceptions

<table>
<thead>
<tr>
<th>Ion</th>
<th>Solubility in water</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrates</td>
<td>Soluble</td>
<td>None</td>
</tr>
<tr>
<td>Ammonium compounds</td>
<td>Soluble</td>
<td>None</td>
</tr>
<tr>
<td>Group I compounds</td>
<td>Soluble</td>
<td>None</td>
</tr>
<tr>
<td>Halides</td>
<td>Soluble</td>
<td>Ag⁺, Cu⁺, Pb²⁺, Hg²⁺</td>
</tr>
<tr>
<td>Sulfates</td>
<td>Soluble</td>
<td>Ag⁺, Pb²⁺, Ba²⁺, Sr²⁺, Ca²⁺</td>
</tr>
<tr>
<td>Carbonates</td>
<td>Insoluble</td>
<td>Group I and ammonium compounds</td>
</tr>
<tr>
<td>Phosphates</td>
<td>Insoluble</td>
<td>Group I and ammonium compounds</td>
</tr>
<tr>
<td>Sulfites</td>
<td>Insoluble</td>
<td>Group I and ammonium compounds</td>
</tr>
<tr>
<td>Sulfides</td>
<td>Insoluble</td>
<td>Group I, Group II, and ammonium compounds</td>
</tr>
<tr>
<td>Hydroxides</td>
<td>Insoluble</td>
<td>Group I and ammonium compounds, Ba²⁺, Sr²⁺, Ti⁺</td>
</tr>
<tr>
<td>Chromates</td>
<td>Insoluble</td>
<td>Group I and ammonium compounds</td>
</tr>
</tbody>
</table>

### Sketch Reaction at Submicroscopic Level

<table>
<thead>
<tr>
<th>Sketch reaction at submicroscopic level time = 0 seconds</th>
<th>Sketch of reaction at submicroscopic level time = 30 seconds</th>
</tr>
</thead>
</table>

### Key

<table>
<thead>
<tr>
<th>complete ionic equation before</th>
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</thead>
</table>

### Net Ionic Equation

### Reaction Type

33. Is this a homogenous or a heterogenous mixture? *Explain your answer.*