Lumpy Liquids

Section CHEMICAL REACTIONS *Topic* BASICS OF CHEMICAL REACTIONS

Estimated Time Setup: 5 minutes; Procedure: 5-10 minutes

OVERVIEW

Students experience a fascinating chemical reaction: precipitation of a solid out of a mixture of solutions!

In this activity, student create two solutions: one with Epsom salt, and the other with powdered laundry detergent. As they slowly add one solution into the other, they will see a solid form. The chemical reaction of two liquid solutions forms a solid right before their eyes.

INQUIRY QUESTIONS

Getting Started:

- How do we know if a chemical or physical reaction has taken place?

Learning More:

- What changes do we observe in a precipitation reaction?

Diving Deeper:

- What is the chemical process by which a precipitate is formed?

CONTENT TOPICS

This activity covers the following content topics: mixtures, solutions, separation techniques, chemical reactions, chemical separations, precipitation, solubility, measurement techniques

This activity can be extended to discuss the following: filtration, physical separations, hard vs. soft water, balancing equations, chemical formulas, aqueous solutions, conservation of mass, double replacement reactions

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **5-PS1-4:** Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- **MS-PS1-2:** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MATERIALS

For one setup:

- Epsom salt
- 1 tsp. powdered laundry detergent containing sodium carbonate (Tide® or Gain® Powdered Laundry Detergent)
- Water (1/2 cup room temperature and 2 tbsp. warm)
- 2 clear plastic cups
- 3 drops food coloring
- Eye dropper
- Teaspoon and tablespoon measurers

ACTIVITY NOTES

This activity is good for:

- Individuals
- Pairs
- Small groups

Safety Tips & Reminders:

- Beware that this activity requires powdered laundry detergent that contains sodium carbonate, which is used as a water softener. Not every brand will have sodium carbonate added, so double check this before purchasing, otherwise the experiment will not work.
- Review the Safety First section in the Resource Guide for additional information.

ENGAGE

Use the following ideas to engage your students in learning about chemical reactions:

- Challenge students to think of how a solid can be made from mixing two liquids. Have they ever experienced this? How might this be possible?
- Demonstrate this experiment but without using any food coloring. As students watch the solid precipitate form, ask them to brainstorm what could be in each solution and how this is possible.
- There are some beautiful examples of precipitation reactions! Check out this one with lead iodide in slow motion or this from the series Beautiful Chemistry.

See more ideas for engagement in the Chemical Reactions Background section! You can also look at the Elaborate section of this activity for other ideas to engage your students.

Fun Fact #1

Epsom salt is hydrated magnesium sulfate, and the name originates from the town of Epsom in England, where water contains high concentrations of this substance.

EXPLORE

Procedure:

1. Add 1/2 cup water and 1 tsp. of Tide® or Gain® powdered laundry detergent to a plastic cup and stir to dissolve.
2. In a second cup, add 2 tbsp. warm water and 1 tbsp. Epsom salt, and stir to dissolve.
3. Add 3 drops of food coloring to the cup containing the Epsom salts.
4. Using the eye dropper, take up some of the colored Epsom salt solution. Submerge the tip of the full eye dropper in the detergent solution.
5. While observing from the side, slowly squeeze the colored Epsom salt solution out of the eye dropper and into the detergent solution. Record your observations.

DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Draw a picture and describe both the Epsom salt and laundry powder solutions.
- Make a prediction: what will happen when you add one solution to the other?
- As you complete step 5, record your observations. What do you see? Why might this be happening?
- Do you think there was a chemical change, physical change, or both in this activity? How do you know? Provide evidence for your answer.

Notes

EXPLAIN continued

What's happening in this Activity?

First review the Basics of Chemical Reactions Background section to gain a deeper understanding of the scientific principles behind this activity.

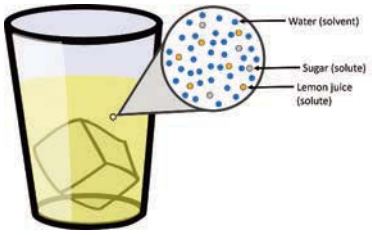
Most of the things around us are mixtures. **Mixtures** are two or more substances that are combined physically. The different substances that are combined to create the mixture are the **components**. Since the parts of the mixture only are combined physically, the chemical compositions of the different parts don't change. For example, in any mixture that contains water, the water will still be composed of oxygen atoms each bonded to two hydrogen atoms.

Since the chemical compositions of the mixture's components remain unchanged, each component in the mixture still has the same physical and chemical properties as it does when it is by itself. Water in a mixture has the same boiling point, density, and reactivity as pure water. A **separation process** divides a mixture of substances into two or more distinct parts based on the different properties of the substances in the mixture.

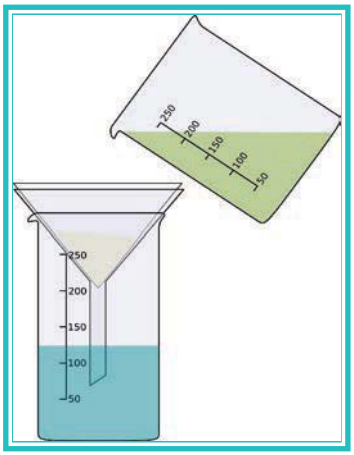
Think of a bowl of trail mix. Each of these parts still has its own unique properties, so we can separate the mixture into the different parts. One physical property that is different is color. Because the parts of the mixture look different, it is easy to pick out the chocolate pieces or the peanuts. This is a physical separation because it uses differences in a **physical property** (color).

Chemical separations use chemical properties to separate a mixture. The components of the mixture react differently because of their unique properties, so a chemical reaction can be used to separate parts of the mixture. Chemical separations are useful for substances that are mixed on a molecular level.

A **solution** is a type of mixture in which one or more substances (called the **solutes**) are dissolved in another substance (called the **solvent**). The different parts of a solution are mixed evenly throughout, so every part of the solution has the same appearance and composition. Lemonade is a solution of lemon juice and sugar (the solutes) in water (the solvent).



One way to separate the parts of a solution by chemical separation is a **precipitation reaction.** During a precipitation reaction, parts of a liquid solution react to form a solid. The solid that forms is called a **precipitate**. Precipitation is useful because it is then easy to separate this solid from the rest of the solution, usually by some physical means.



The precipitate is usually isolated by **filtration**, which is a physical separation process that separates components based on particle size. The mixture is passed through filter paper, which has very small pores (or holes). Filtration is often used to separate solids and liquids. The liquid parts of the mixture can pass through the holes in the filter, but the solid parts cannot. The liquid that flows through the filter paper, which does not contain any solid particles, is called the **filtrate**.

We use filtration after we cook pasta in water. Once the pasta is done, it is poured through a strainer with holes that allow water – but not the cooked pasta – to pass through. We also use filtration to make tea and coffee, but with a filter (the tea bag or paper coffee filter) with much smaller holes so that the tea leaves and coffee grounds cannot pass through.

EXPLAIN continued

In this experiment, Epsom salt (the solute) is mixed with water (the solvent) to create an Epsom salt solution. A second solution of powdered laundry detergent dissolved in water is also created. In this solution, laundry detergent is the solute and water is the solvent.

Epsom salt is made of a compound called magnesium sulfate, which has the formula $MgSO_4$. The powdered laundry detergent contains a compound called sodium carbonate, which has the formula Na_2CO_3. Sodium carbonate, commonly known as soda ash, is used as a water softener to prevent clothing from being harmed while it is in the wash. Most water has many minerals dissolved in it, and is known as "hard water." Water softeners remove the dissolved minerals from hard water through precipitation.

When the Epsom salt solution and laundry detergent solutions are mixed, the magnesium sulfate in Epsom salt and the sodium carbonate in laundry detergent react to form a precipitate. Magnesium carbonate, a new solid with the formula $MgCO_3$, is formed. Sodium sulfate, Na_2SO_4, is also formed, but it stays dissolved in the water. In the chemical equation below, (aq) means that a compound is "aqueous," or dissolved in water. A compound with (s) next to it is a solid.

Dissolved magnesium sulfate	+	Dissolved sodium carbonate	→	Solid magnesium carbonate	+	Dissolved sodium sulfate
$MgSO_4(aq)$	+	$Na_2CO_3(aq)$	→	$MgCO_3(aq)$	+	$Na_2SO_4(aq)$

The precipitate, solid magnesium carbonate, could be easily separated using filtration. If the mixture was poured through filter paper, the water and all the dissolved compounds would pass through the paper, but the precipitate (magnesium carbonate) would be unable to pass.

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED

For younger students, emphasize the following concepts:

- Physical and chemical properties of mixtures
- Separating components of mixtures

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- Chemical equations and reactions
- Precipitation reactions
- Filtration

Fun Fact #2

Epsom salt is often used as a plant fertilizer because the sulfur it contains aids plants' production of vitamins, amino acids, and enzymes.

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- Take the experiment one step further: filter out the precipitate. Place filter paper (or a paper towel or coffee filter) over a third cup and pour the solution with the precipitate over it. The filter paper will retain the precipitate since the particles are too big to pass through the pores in the paper. Students can then examine the precipitate more closely.
- Make connections to more separation techniques (see the Separation Techniques activities!). Students can try the processes of filtration, decanting, and centrifugation. Which is most effective? Which is most efficient?
- Make a more colorful experiment by having samples of the Epsom salt solution dyed different colors. Use a separate eye dropper in each dyed solution. Students can then form different colored precipitates within their laundry detergent solution.
- Extend this into a study on conservation of mass. Students can record the mass of the solutions in step 3, and then the mass again in step 5. Are they the same or different? Students can remove the precipitate and measure that separately as well!
- Prior to the experiment, ask students to brainstorm what changes indicate that a chemical reaction has occurred. After completing their experiment, ask them to refer to their brainstorming again: did a chemical reaction take place? What evidence do they have?
- For more advanced students: ask them to research the reactants and write the chemical formulas for them. Can they determine the chemical formulas for the products? Is this equation balanced? Which is the insoluble precipitate?

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

Precipitation reactions are one of the many techniques used to clean water so it is safe for human consumption.

Precipitation reactions happen all around us! Have you ever noticed deposits in kettles, pots or pans, or even in the bathtub or sink? Those might in part be due to minerals that precipitated out of your water and were left behind as solids in your home!.

The process of precipitation is used to separate silver from natural spring water. In the water, the silver is dissolved. It can be removed by adding potassium chloride (KCl). The reaction between the silver and the potassium chloride creates a solid silver compound that can then be processed further to remove pure silver.

Careers in Chemistry

- Performing a precipitation reaction is one of the ways to get the purest product in a separation. Chemists use this technique to ensure they get the best separation possible during a chemical reaction.
- Solid Solution Strengthening is a technique that uses precipitation to make metals stronger by adding other chemicals to them. For example, steel is made from iron that is strengthened with things like carbon, nickel, copper, and more.

Notes

EVALUATE

- Ask students if they can write a description of what happened in the reaction along with evidence for why a chemical change took place.
- Ask students to research other precipitation reactions online. Instruct them to share what they learn about the reactants and products, including the precipitate, with a peer. Request that they use a visual aide.
- For advanced students: ask them to draw out the steps of the reaction, along with the chemical formulas, to show how the substances move and recombine.