LESSON 5: Lumpy Liquids

ESTIMATED TIME **Setup:** 5 minutes | **Procedure:** 5–10 minutes

DESCRIPTION

Combine two solutions to form a solid and demonstrate the process of precipitation.

OBJECTIVE

This lesson demonstrates an important chemical separation process called precipitation. Students will combine Epsom salt and detergent solutions to observe precipitation. The lesson can be extended to discuss solubility.

CONTENT TOPICS

Scientific inquiry; measurement; mixtures (solutions); separation processes (precipitation); chemical reactions

This experiment requires sodium carbonate, which is found in some powdered laundry detergents as a water softener. Many brands do not contain sodium carbonate, so be sure to find a detergent that does. Test the experiment before class to make sure the proper chemical reaction occurs.

MATERIALS

- ❑ Epsom salt
- ❑ Powdered laundry detergent (containing sodium carbonate)
- ❑ Water
- ❑ Clear plastic cups
- ❑ Food coloring
- ❑ Eye dropper
- ❑ Measuring spoons

Always remember to use the appropriate safety equipment when conducting your experiment. Refer to the ***Safety First*** section in the ***Resource Guide*** on pages 421–423 for more detailed information about safety in the classroom.

Jump ahead to page 71 to view the Experimental Procedure.

NATIONAL SCIENCE EDUCATION STANDARDS SUBJECT MATTER

This lesson applies both *Dimension 1: Scientific and Engineering Practices* and *Dimension 2: Crosscutting Concepts* from "A Framework for K–12 Science Education," established as a guide for the updated National Science Education Standards. In addition, this lesson covers the following Disciplinary Core Ideas from that framework:

- PS1.A: Structure and Properties of Matter
- PS1.B: Chemical Reactions
- ETS2.A: Interdependence of Science, Engineering, and Technology (see ***Analysis & Conclusion***)

OBSERVATION & RESEARCH

BACKGROUND

Most of the things around us are mixtures. **Mixtures** are two or more substances that are combined physically. A **solution** is a uniform mixture in which one or more substances (solutes) are dissolved into another substance (solvent). Epsom salt is combined with water to create an Epsom salt solution.

Chemists often need to separate a specific chemical substance (a specific part) from a mixture. Separating a mixture of substances into two or more distinct products is called a **separation process**. A separation process uses the different properties of a mixture's parts to get them to separate. A mixture can be separated either through physical or chemical means.

A physical separation process uses physical properties to separate the parts of a mixture. This separation is accomplished without changing the chemical properties of the parts. Common physical separation processes include filtration and distillation.

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A chemical separation requires some type of chemical reaction to take place, such as the process of precipitation. **Precipitation** is a separation process in which a solid is formed in a solution following a chemical reaction. After the chemical reaction, the solid that forms in the solution is called a **precipitate**. This process is called precipitation because the precipitate tends to sink, or fall, to the bottom of the liquid. Precipitation is very useful because it allows chemists to isolate specific substances from a mixture of many chemicals.

Once a precipitate has formed, it can be removed from the solution through a physical separation process. This separation is often accomplished through the use of filtration. **Filtration** is a process by which a mixture is separated based on the sizes of the parts that make up the mixture. Filter paper is often used to separate solid particles from a liquid. Filter paper comes in different grades. These grades represent the size of the tiny pores in the paper. The pores allow the liquid to pass through but not the larger solid particles. The liquid that flows through the paper is called the **filtrate**. The filtrate is free of the solid particles.

In this experiment, the chemical reaction between the Epsom salt and the powdered laundry detergent creates a precipitate. The precipitate can be removed from the solution by using filter paper.

Fun Fact

Epsom salt is named after a town in Surrey, England. The water of the natural spas in this town contains high concentrations of the salt magnesium sulfate.

CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on mixtures, chemical changes, and separation processes can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.

FORMULAS & EQUATIONS

Epsomite, commonly known as Epsom salt, is hydrated magnesium sulfate.

The chemical formula for Epsom salt is **$MgSO_4 \cdot 7(H_2O)$**.

In this experiment, the Epsom salt is mixed with water to create an Epsom salt solution.

Some powdered laundry detergent contains the compound sodium carbonate. Commonly known as soda ash, sodium carbonate works as a water softener to prevent clothing from being damaged. ("Hard water" contains a larger amount of dissolved minerals.)

The chemical formula for sodium carbonate is **Na_2CO_3**.

The chemical reaction between the magnesium sulfate and the sodium carbonate produces the precipitate magnesium carbonate, $MgCO_3$, and the byproduct sodium sulfate, Na_2SO_4.

$MgSO_4$ (aq) + Na_2CO_3 (aq) → $MgCO_3$ (s) + Na_2SO_4 (aq)

By filtering the solution, you can separate the magnesium carbonate from the sodium sulfate.

HYPOTHESIS

▶When Epsom salt and certain detergent solutions are combined, a chemical reaction will produce a new solid substance that can be separated from the liquid.

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DIFFERENTIATION IN THE CLASSROOM

LOWER GRADE LEVELS/BEGINNERS

Conduct the experiment as described on page 71, but spend more time on the concepts of mixtures, solutions, and chemical reactions. Use pictures and have students write down or state their answers of whether a certain substance is a solution or simply a mixture. For example, show a picture of apple juice—a solution. Show a picture of a garden salad—a mixture. After students complete this exercise, be sure to remind them that solutions are a type of mixture. The apple juice is a solution *and* a mixture!

Likewise, use a similar method to go over chemical reactions in more detail. Show a picture of a raw biscuit and then a fluffy, baked biscuit. Ask them how they know a chemical reaction took place.

HIGHER GRADE LEVELS/ADVANCED STUDENTS

DESCRIPTION

Combine two soluble salt solutions to form an insoluble solid and demonstrate the process of precipitation.

OBJECTIVE

This lesson demonstrates an important chemical separation process called precipitation and incorporates the concept of solubility.

OBSERVATION & RESEARCH

A **solution** is a uniform mixture in which one or more substances (solutes) are dissolved in another substance (solvent). For example, salt may be dissolved in water to form a saltwater solution. The salt is the solute, and the water is the solvent.

Solubility is a physical property that describes the ability of a chemical substance (the solute) to dissolve in a solvent to create a uniform solution. A substance that dissolves in another substance is **soluble**. For example, salt is soluble in water. If a substance does not dissolve, it is **insoluble**. For instance, butter is insoluble in water.

When solutions of two soluble salts are mixed, a chemical reaction may occur, forming a new solid substance. The solid that forms from the combined solutions is called a **precipitate**, and the reaction is called a **precipitation** reaction. Precipitation reactions can be used to produce insoluble salts. In this experiment, the soluble salts are magnesium sulfate (Epsom salt) and sodium carbonate (an ingredient in the powdered laundry detergent). The two soluble salts are dissolved in water to form aqueous solutions. An **aqueous solution** is any solution in which the solvent is water. When the two solutions react, another salt—magnesium carbonate—forms. Magnesium carbonate is insoluble in water.

CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on precipitation and solubility can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.
- Additional information on solutions can be found in the Chemicals by Volume—Solutions section of CEF's *Passport to Science Exploration: Chemistry Connections*.

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EXPERIMENTATION

As the students perform the experiment, challenge them to identify the independent, dependent, and controlled variables, as well as whether there is a control setup for the experiment. (Hint: If the amount of Epsom salt solution added to the laundry detergent solution changes, do the results change?) Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss variables.

EXPERIMENTAL PROCEDURE

1. Place ½ cup of water in a plastic cup, and add one teaspoon of powdered laundry detergent. Stir until no more detergent will dissolve.
2. In another cup, add two tablespoons of warm water. Add one tablespoon of Epsom salt, and stir until Epsom salt will no longer dissolve.
3. Add three drops of food coloring to the cup containing the Epsom salt solution.
4. Use the eye dropper to pick up some of the colored Epsom salt solution and then submerge the tip of the dropper into the detergent solution. Look from the side and slowly squeeze out the solution. Observe the formation of a precipitate.

DATA COLLECTION

Have students record data in their science notebooks or on the following activity sheet. What are the physical properties of Epsom salt? What are the physical properties of the laundry detergent? What occurs when solutions of both chemicals are combined? Have students answer the questions on the activity sheet (or similar ones of your own) to guide the process.

NOTES

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ANALYSIS & CONCLUSION

Use the questions from the activity sheet or your own questions to discuss the experimental data. Ask students to determine whether they should accept or reject their hypotheses. Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss valid and invalid hypotheses.

ASSESSMENT/GOALS

Upon completion of this lesson, students should be able to …

- Apply a scientific inquiry process and perform an experiment.
- Understand the importance of taking careful measurements.
- Compare and contrast mixtures and solutions.
- Define and identify chemical reactions.
- Differentiate between physical and chemical separation processes.
- Understand that precipitation is a separation process involving a chemical reaction.
- Define and identify solutions and the parts of a solution.
- Explain solubility and ways to change the solubility of a solution (see ***Differentiation in the Classroom***).

MODIFICATIONS/EXTENSIONS

Modifications and extensions provide alternative methods for performing the lesson or similar lessons. They also introduce ways to expand on the content topics presented and think beyond those topics. Use the following examples, or have a discussion to generate other ideas as a class.

- Before the experiment, ask the students what they know about precipitation in chemistry. Most likely, they will think you are talking about the weather. Tell them that two liquids can be mixed to form a solid and ask how this is possible—chemical reactions!
- Make the experiment more colorful! You can make different colored Epsom salt solutions and add them to the detergent solution to create colorful, layered precipitate designs.
- Use filter paper to filter the precipitate from the solution to demonstrate another separation technique —a physical one!

REAL-WORLD APPLICATIONS

- 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 to remove the pure silver.

COMMUNICATION

Discuss the results as a class and review the activity sheet. Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss the importance of communication to scientific progress.

Fun Fact

Sodium carbonate is found naturally in high concentrations in the soda lakes of Kenya and Tanzania.

LESSON 5 ACTIVITY SHEET: Lumpy Liquids

OBSERVE & RESEARCH

1. Write down the materials you observe. _____

_____

_____

2. Predict how these materials may be used. _____

_____

_____

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

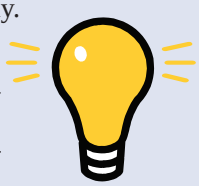
Term	Definition	Example (write or add image)
Mixture		
Solution		
Separation process		
Precipitation		
Precipitate		
Filtration		

4. Consider what will happen if an Epsom salt solution is added to a laundry detergent solution and why.

▶**Write your hypothesis.** _____

_____

_____



LESSON 5 ACTIVITY SHEET: Lumpy Liquids

PERFORM YOUR EXPERIMENT

1. Place ½ cup of water in a plastic cup. Then, add one teaspoon of powdered laundry detergent. Stir until no more detergent will dissolve.
2. In another cup, add two tablespoons of warm water. Then, add one tablespoon of Epsom salt. Stir until no more Epsom salt will dissolve.
3. Add three drops of food coloring to the cup containing the Epsom salt solution.
4. Use the eye dropper to pick up some of the colored Epsom salt solution. Then, submerge the tip of the dropper into the detergent solution.
5. Slowly squeeze out the Epsom salt solution. Look from the side to see what happens.

ANALYZE & CONCLUDE

1. Describe the detergent solution. _____

_____

_____

2. Describe the Epsom salt solution. _____

_____

_____

3. What happens when you place the Epsom salt solution into the detergent solution? _____

_____

_____

4. Is your hypothesis valid? Why or why not? If not, what would be your next steps? _____

_____

_____

LESSON 5 ACTIVITY SHEET: Lumpy Liquids

EXPAND YOUR KNOWLEDGE—ADVANCED

1. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Solubility		
Soluble		
Insoluble		
Aqueous solution		

2. Why might chemists use precipitation reactions? _____

_____

_____

3. How could you remove the precipitate that formed during the reaction? _____

_____

_____

4. List some other substances that are insoluble in water. _____

_____

_____

LESSON 5 ACTIVITY SHEET: Lumpy Liquids

ANSWER KEY: *Below are suggested answers. Other answers may also be acceptable.*

OBSERVE & RESEARCH

1. Write down the materials you observe. Epsom salt, powdered laundry detergent, food coloring, measuring spoon …

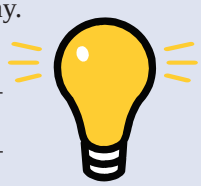
2. Predict how these materials may be used. The Epsom salt may be mixed with water and used to soothe aches and pains. Laundry detergent may mix with water and be used to kill bacteria and clean materials. Food coloring may be used to dye materials. Measuring spoons are used to portion out substances. These different materials may be combined to create a new substance.

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Mixture	A physical combination of two or more substances that can be physically separated.	
Solution	A homogeneous (uniform) mixture in which one or more substances (solutes) are dissolved in another substance (solvent).	
Separation process	A process that divides a mixture into two or more distinct substances.	
Precipitation	A separation process that separates a particular component from a solution by reacting the solution with another substance to form a solid.	
Precipitate	An insoluble solid that forms from a liquid solution following a chemical reaction.	
Filtration	A separation process that uses the different sizes of a mixture's parts to separate those parts.	

4. Consider what will happen if an Epsom salt solution is added to a laundry detergent solution and why.

▶**Write your hypothesis.** When Epsom salt and detergent solutions are combined, a chemical reaction will take place to form a new solid substance. Then, the solid can be separated from the liquid through a physical separation process.



LESSON 5 ACTIVITY SHEET: Lumpy Liquids

ANSWER KEY: *Below are suggested answers. Other answers may also be acceptable.*

PERFORM YOUR EXPERIMENT

1. Place ½ cup of water in a plastic cup. Then, add one teaspoon of powdered laundry detergent. Stir until no more detergent will dissolve.
2. In another cup, add two tablespoons of warm water. Then, add one tablespoon of Epsom salt. Stir until no more Epsom salt will dissolve.
3. Add three drops of food coloring to the cup containing the Epsom salt solution.
4. Use the eye dropper to pick up some of the colored Epsom salt solution. Then, submerge the tip of the dropper into the detergent solution.
5. Slowly squeeze out the Epsom salt solution. Look from the side to see what happens.

ANALYZE & CONCLUDE

1. Describe the detergent solution. The detergent solution is very cloudy with a white tint.

2. Describe the Epsom salt solution. The Epsom salt solution takes on the color of the food dye, but is fairly transparent once the salt is dissolved.

3. What happens when you place the Epsom salt solution into the detergent solution? When the Epsom salt solution is placed into the detergent solution, two soluble salts, magnesium sulfate (Epsom salt) and sodium carbonate (ingredient in detergent), create a chemical reaction that produces a solid (precipitate). These tiny solids form and fall to the bottom of the glass.

4. Is your hypothesis valid? Why or why not? If not, what would be your next steps?

Answer 1: Valid because the data support my hypothesis.

Answer 2: Invalid because the data do not support my hypothesis. I would reject my hypothesis and could form a new one, such as …

LESSON 5 ACTIVITY SHEET: Lumpy Liquids

ANSWER KEY: *Below are suggested answers. Other answers may also be acceptable.*

EXPAND YOUR KNOWLEDGE—ADVANCED

Have students complete this section if you used the advanced differentiation information, or challenge them to find the answers to these questions at home and discuss how these terms relate to the experiment in class the next day.

1. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Solubility	A measure of the amount of solute that can be dissolved in a solvent.	
Soluble	The ability of a substance to dissolve in another substance.	
Insoluble	The inability of a substance to be dissolved into another substance.	
Aqueous solution	A solution in which the solvent is water.	

2. Why might chemists use precipitation reactions? Chemists often need to separate a specific chemical or compound from a mixture of several different substances. Precipitation allows chemists to isolate specific substances from a mixture of many chemicals.

3. How could you remove the precipitate that formed during the reaction? The precipitate can be removed through filtration. Filtration is a physical separation method that uses the size of the parts that make up the mixture to separate those parts; this can be done using filter paper.

4. List some other substances that are insoluble in water. Butter, oil, and other fats are insoluble in water.