



Elements from the Earth: Exploring Brine Chemistry in the Smackover Formation

This STEM activity was designed for the LITHIUMLEARN'S HIRED Grant program.

Elements from the Earth: Exploring Brine Chemistry in the Smackover Formation (Elementary)

Students will learn what brine is, conduct simple chemical tests in the classroom, and connect their findings to local industry in South Arkansas.

Arkansas Science Standards Alignment (2nd Grade)

- 2-PS1-1: Compare properties of salt vs. fresh water
- 2-PS1-2: Test materials using dissolving, evaporation, and conductivity
- 2-PS1-4: Observe reversible change (dissolved salt → evaporated crystals)

Materials & Setup

Station	Materials
Solubility	Clear cups, distilled water, salt samples
Evaporation	Saltwater from prior station, heat lamp or warm area, evaporation dishes
Conductivity	Battery (9 V), LED or bulb, wires, alligator clips
Observation	Magnifying glasses or microscopes

Intro:

- Present info on South Arkansas's brine extraction
- Show students saltwater (or bring a "brine" photo).
- Ask: *"What's in this water? What could we find if we look closely?"*

Procedure

- Set up rotation stations:
- Station 1 – Solubility: Add salt to water, stir, observe disappearance.
 - Discuss that salt dissolves into saltwater (forming brine)
- Station 2 – Evaporation: Heat saltwater; after evaporation, observe salt crystals.
 - Discuss how solutions evaporate into crystals.
- Station 3 – Conductivity: Build a simple circuit to compare pure vs. salt water.
 - Demonstrate circuit and explain ions conduct electricity.

Data Collection:

- Record observations: drawings, notes, and conclusions for each station.
- Write an explanation of one test (e.g., "When I evaporated saltwater, crystals formed because water left and salt stayed").
- Grade 4: Estimate amount of salt recovered; measure mass pre/post evaporation.



Discussion:

- Discuss the importance of chemical analysis in the brine industry.
- Connect classroom evaporation to industrial mineral recovery.
- Students draw a “brine recipe”: water + salt + minerals



Elements from the Earth: Exploring Brine Chemistry in the Smackover Formation (Middle School)

Students perform chemical analysis of brine and connect it to local lithium and bromine extraction processes in South Arkansas.

Arkansas Science Standards Alignment (Middle School)

- **MS-PS1-2:** Analyze and interpret data from student-designed chemical testing.
- **MS-PS1-3:** Gather evidence about reversible physical vs. chemical changes.

Materials and Stations:

Station	Materials
Solubility & Crystallization	Clear beakers, brine sample, distilled water, balance, hot plate
Conductivity	9 V battery, LED, wires, two sample beakers
pH Analysis	pH strips or safe indicators (e.g., red cabbage juice)

Intro:

- Show photos/diagram of Smackover brine extraction and plant: highlight bromine recovery since the 1950s and new lithium extraction
- Explain **Smackover Formation** (~1,400–2,500 ft below surface) brine with bromine and lithium.
- Show how **direct lithium extraction (DLE)** plants separate lithium using filtration and chemistry in hours
- Present concepts of solutions, pH, conductivity, and crystallization.

Procedure:

- **Teacher Prep:**
 - Prepare classroom “brine” by dissolving table salt plus a small measure of Epsom salt or commercially available “bromine substitute” to model mineral-laden brine.
 - Pre-warm brine for evaporation activity.
- **Explore Experiments** (rotating groups):
 - **Dissolving:** Weigh 50g distilled water, add salt/mineral blend until dissolution stops. Record mass of dissolved material.
 - **Conductivity:** Set up LED + wires + battery. Test pure vs. brine. Record LED brightness (e.g., on/off, dim, bright). Enhance understanding by using a multimeter in the circuit.
 - **pH Test:** Measure pH of brine and plain water.
 - **Evaporation (in progress):** Begin heating brine for later. Heat 100 mL brine until fully evaporated. Cool, weigh residue, observe crystal structure.



Data & Analysis

- Build a **data table**: sample, mass dissolved, crystal mass, pH, conductivity result.

Discussion:

- Discuss the importance of brine characterization for industry.
- Consider careers in chemistry, geology, engineering.



Elements from the Earth: Exploring Brine Chemistry in the Smackover Formation (High School)

Students will analyze the chemical composition of synthetic brine using solubility, pH, conductivity, and precipitation reactions. They will also model the chemical analysis done as part of the brine extraction process.

Arkansas Science Standards Alignment (High School)

- CHEM-PS1-2: Construct explanations for properties of substances based on atomic and molecular structure.
- CHEM-PS1-3: Plan and conduct investigations to compare properties of ionic vs. molecular compounds (e.g., conductivity of brine).
- CHEM-PS1-5: Develop models to illustrate conservation of mass and the role of precipitation in ionic reactions.
- CHEM-ESS3-1: Evaluate or refine technological solutions that reduce impacts of human activities on natural systems (e.g., DLE lithium extraction).
- ENVSCI-ESS3-1: Analyze geoscience data to identify areas with natural resources and discuss resource availability's impact.
- ENVSCI-ETS1-1: Evaluate sustainability and environmental consequences of industrial resource extraction.

Materials:

- NaCl
- MgCl_2
- CaCl_2
- NaBr (optional)
- Distilled water
- Multi Meter
- 9V battery
- LED
- Alligator clips
- AgNO_3
- Na_2CO_3
- Dish for Evaporating
- Microscope
- pH meter

Intro:

- Show photos/diagram of Smackover brine extraction and plant: highlight bromine recovery since the 1950s and new lithium extraction
- Explain **Smackover Formation** (~1,400–2,500 ft below surface) brine with bromine and lithium.
- Show how **direct lithium extraction (DLE)** plants separate lithium using filtration and chemistry in hours.
- Present concepts of solutions, pH, conductivity, precipitation from solution, and crystallization.



Procedure:

- Station 1: Brine Composition and Solubility
 - Objective: Determine maximum solubility and identify major ions in synthetic brine.
 - Prepare 100 mL samples of "brine" (NaCl, MgCl₂, CaCl₂, optional: NaBr or food-safe bromine simulant).
 - Weigh solute before and after dissolution; calculate solubility (g/100 mL).
 - Observe differences in solution clarity and crystallization behavior.
- Station 2: Electrical Conductivity
 - Objective: Relate ion concentration to conductivity using multimeters or LED circuits.
 - Test distilled water, salt water, and synthetic brine.
 - Use a multimeter to measure conductivity (μS/cm) or create a qualitative scale using LED brightness.
 - Calculate correlation between ion concentration and conductivity.
- Station 3: Precipitation Reactions
 - Objective: Identify ions through double displacement reactions.
 - Use AgNO₃ to test for Cl⁻ (forms AgCl white precipitate).
 - Use Na₂CO₃ to test for Ca²⁺ and Mg²⁺ (forms cloudy carbonate precipitates).
 - Write balanced chemical equations for reactions.
- Station 4: Evaporation and Crystallization
 - Objective: Use controlled evaporation to recover solid minerals.
 - Evaporate 50–100 mL of brine in an evaporating dish (can be prepped overnight).
 - Weigh residue and calculate % yield.
 - Optional: Examine crystals under microscope for structure analysis.
- Station 5: pH and Acid/Base Reactions
 - Objective: Measure the pH of brine before and after extraction to analyze chemical environment.
 - Use pH meter or universal indicator.
 - Add acids or bases (HCl/NaOH, as appropriate) to simulate pH shifts in lithium separation.

Data Collection:

- Data tables, calculations (concentration, % yield), pH, precipitation observations, conductivity, crystal observations.



Discussion:

- How does temperature affect solubility in brine? How do industrial facilities manage solubility when scaling up extraction?
- How is this principle used in DLE (Direct Lithium Extraction) systems to detect when lithium is present in solution?
- How do industrial chemists use precipitation to separate minerals in the brine?
- Discuss how DLE uses resin or membrane systems sensitive to pH.
- Choose a company operating in South Arkansas. Analyze its technology, sustainability efforts, and community impact.

