UTAH OFFICE OF
ENERGY DEVELOPMENT

Lithium Mining in Utah

Grade/Subject: Chemistry

Stand/Standard CHEM.3.5 Develop solutions related to the management, conservation, and utilization of mineral resources (matter). Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize the conservation of matter and minerals as a limited resource. Examples of Utah mineral resources could include copper, uranium, potash, coal, oil, or natural gas. Examples of constraints could include cost, safety, reliability, or possible social, cultural, and environmental impacts. (PS1.B, ESS3.A, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations:

- Students will design a method to extract a mineral from a solution, similar to the extraction of lithium from underground sources. They will evaluate the environmental impacts and mitigation costs with the societal demand for lithium in energy storage.

Materials per group:

- Flasks of several sizes (one per group)
- Filter paper (filter needs to fit in funnel, usually 6 cm diameter)
- Funnel
- Flat dishes
- Hot plates
- Blow dryer
- Small ziplock bags
- Ice
- Potassium Nitrate (in place of lithium) solution
- Graduated cylinder

Time: 1-2 class periods

Teacher Background Information: KNO3 (Potassium Nitrate) is very soluble in hot water and creates a solution that will precipitate out the potassium nitrate as it cools and the water evaporates. While lithium salts are not heated the process is much the same, water is evaporated out of the solution leaving behind the lithium. Potassium nitrate is moderately soluble in water, but its solubility increases with temperature. It is insoluble in alcohol and is not poisonous; it can react explosively with reducing agents, but it is not explosive on its own.
https://www.bbc.com/future/article/20221110-how-australia-became-the-worlds-greatest-lithium-supplier
https://www.npr.org/2022/11/12/1131365516/a-proposed-lithium-mine-presents-a-climate-versus-environment-conflict

Student Background Knowledge:

- Students should know that lithium batteries are increasingly important to battery-powered cars and wireless devices that depend on a battery.
- Students should have had basic safety training in goggle wearing, handling of chemicals and glassware.

Teacher Step by Step: A 3-D lesson should insist that students think deeply. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. Set up a flask with 500 mL of water and place it on a hot plate. On a low heat, add KNO3 until a concentrated solution is reached. Keep it warm as class starts. The amount is about 100g. Varies with the heat. Warm water is fine.
2. Students should begin by reading the information on the student sheet.
3. Ask students for questions that they have about the reading.
4. Show students the materials they have available and provide time for them to assemble them. If you wish to provide "sunlight" without a window or going outside, place a heat lamp in a couple of areas in the classroom.
5. Deliver the KNO3 to students about the same time. Pour 50 mL into beakers and distribute quickly.
6. Let students know how much time they will have (20 minutes or so). During this time instruct students how to use the filter and funnel. They should pre-weigh their filter.
7. When time is up, students should pour and/or scrape the remainder of their solution into the filter and allow it to drip. The filter should be weighed after it dries. If time allows, mass the filter then next day. They can begin to report to the class how they set up their experiment to fill in the data table.

Assessment of Student Learning.

1. What condition is lithium found in Utah?
    a. Dispersed in soil, rock and surface water*
    b. As a solid inside metamorphic rock.
    c. In volcanic areas
    d. In high elevations.

2. How is lithium purified for use?
    a. By evaporating the water out of solution.*
    b. By blasting away the surrounding rock.
    c. By searching for areas with melting lava.
    d. By sending mining operators to mountain peaks.

3. What is the need for better and more efficient lithium batteries? Choose all that apply.
    a. Storing energy from renewable energy sources.*
    b. Adding additional weight to electrical devices.
    c. Collecting and using energy from earth materials.
    d. Reducing pollution and carbon dioxide production.*

4. Which conditions are necessary to quickly and inexpensively recover lithium found in Utah? Choose all that apply.
    a. Maximum surface area for evaporation*
    b. Adding heat from renewable sources*
    c. Creating deep evaporative basins.
    d. Adding additional substances to the lithium mixture.

5. What environmental impacts must be considered before allowing a lithium mine to exist in a location? Choose all that apply.
    a. Damage to land surface*
    b. Depletion of underground water*
    c. Transportation distance to manufacturing plant.*

d. Ability of lithium to be added to a battery.
Extension of lesson and Career Connections: Magnesium is currently mined in Utah in the same way that Lithium is mined. Research and report on magnesium or lithium mining that is already occurring in Utah.

Title: Lithium in Utah **Name_____**

Introduction: Lithium is a metal found in many Earth materials. In recent years it has been widely used in battery technology. Batteries provide energy storage necessary for alternative energy sources like solar and wind that capture energy but cannot store it.

What are the advantages of Lithium use in batteries?

Li-ion (lithium ion) batteries have one of the highest energy densities of any battery technology today. Li-ion battery cells can deliver large amounts of current for high-power applications. Li-ion batteries are also comparatively low maintenance, and do not require scheduled cycling to maintain their battery life. Li-ion batteries have no memory effect which may reduce the power of the battery. Li-ion batteries also have a low self-discharge rate of around 1.5-2% per month. They do not contain toxic cadmium, which makes them easier to dispose of than Ni-Cd batteries.

What are disadvantages?

Li-ion batteries have a tendency to overheat, and can be damaged at high voltages. In some cases this can lead to combustion. Li-ion batteries require safety mechanisms to limit voltage and internal pressures, which can increase weight and limit performance in some cases. Li-ion batteries are also subject to aging and frequently fail after a number of years. Another factor is their cost, which is around 40% higher than Ni-Cd. **Finally, despite the high energy density of Li-ion compared to other kinds of batteries, they are still around a hundred times less energy dense than gasoline.**

https://www.cei.washington.edu/education/science-of-solar/battery-technology/

Utah soils have lithium.

Lithium is relatively abundant. The trouble, experts say, is accessing and concentrating it. Minute quantities of lithium are scattered throughout soils across the globe, but in most cases, the lithium is so diffuse that attempting to mine it would never be sufficiently efficient.

Utah is an exception to this rule. Before it dried up 12,000 years ago, Lake Bonneville swept lithium from the surrounding rocks and concentrated the mineral in its sediment. That concentrated source of lithium remains present in Bonneville remnants around the state, including the Great Salt Lake, the Bonneville Salt Flats, and Sevier Lake. Underground reservoirs of saltwater brines that contain lithium are also scattered across southeastern Utah.

“In order to get these brines, you have an evaporative process working,” says Andrew Rupke, a senior minerals geologist for the Utah Geological Survey. “That concentrates ions in the brine, and that increases in concentration as you evaporate more and more water. Lithium tends to stay in the brine—you have to evaporate everything before you get lithium depositing as a solid.”

https://www.utahbusiness.com/lithium-mining-in-utah-is-a-big-deal/

Question: How can you extract the most "lithium" using the least energy?

Materials: **F**lasks of several sizes, evaporating dishes, hot plates, Potassium Nitrate (in place of lithium) solution, graduated cylinders, filter, funnel, scale, blow dryer (wind), heat lamp(the sun), hot plate (hydrocarbon fuel source)

Procedures:

1. Design a process to evaporate the water from 50 mL of the KNO3 solution (brine) your teacher provides. The goal is to reduce the water content quickly, use the least energy and produce the most KNO3.
2. Choose your materials from those provided and set up your equipment. Use the data table to find out the points for each choice. The goal is the LOWEST score except for the amount of KNO3 produced. Extra evaporation dishes require points. (extra large dish=-2 pts, extra small dish=-1 pt.
3. Draw your experimental set-up here:

4. You will receive your 50 mL of the "brine" at about the same time as other groups. Begin your process and keep track of the time when you start and when you finish. Your maximum time is 20 minutes.
5. When time is up, weigh the solid. Subtract the mass of the filter paper or weighing cup.
6. Fill in the data table with information from other groups in your class.

Data

Group #	Evaporation method	Energy Required high/med/low 16 8 3	Extra evaporation dishes	Time Needed high/med/low 6 3 1	Grams of KNO3 produced (rank order)
1					
2					
3					
4					
5					
6					

Followup questions

Analysis:

1. Which methods were most successful?

2. Which design used the least energy? Why?

3. Which design was most energy efficient? Why?

4. What advantages does Utah have in terms of mining lithium?

5. Name several devices you know of that contain lithium batteries: