NSF RET Lesson

Lesson Title: Batteries and Electrolytes	**Grade Level/Subject:** 10^{th} Grade Chemistry
Maximum # of Students: Students in Classroom	**Total Time Required:** 3 Class Periods

Prior Knowledge Needed:

Two-Cell Battery
https://www.teachengineering.org/activities/view/cub_electricity_lesson03_activity2

Materials:

• 2 - 400 mL Beakers • 100 mL Graduated Cylinder • DC Ammeter • Small Paper Dixie Cups • 2 pieces of Aluminum Foil (8 in x 12 in) • Alligator Clips • Non-insulated Copper Wire (75 inches) • Wire Cutters	• Various Electrolyte Solutions • 400 mL of each solution • Weak solution: 5 ml (~1 teaspoon) of [vinegar or citrus juice or salt] for every 100 ml water • Medium solution: 15 ml (~1 tablespoon) of [vinegar or citrus juice or salt] for every 100 ml water • Strong solution: 40 ml (~2.5 tablespoon) of [vinegar or citrus juice or salt] for every 100 ml water

Performance Objectives/Learning Targets:

- Students will analyze the components of a battery and apply what they learn to create a more efficient battery.
- Students will be able to distinguish the individual components of a battery and compare various electrolyte solutions to best increase energy efficiency.
- Students will have a preliminary discussion/lecture to determine what they know and understand about batteries and electrolytes.
- Students will take a test prior to the lesson to assess what knowledge they have gained or obtained during the lesson

Standards:

Students who demonstrate understanding can:

HS-ETS1-3. **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Lesson Procedure	
Pre-Lab Day 1:	• Students will need to cut two 8 in x 12 in (20 cm x 30 cm) pieces of aluminum foil for each team. Also, Cut one 12 in (30 cm) piece and two 31.5 in (80 cm) pieces of wire for each team. Note that insulated wire can be used, as long as it is stripped at the ends. • Each Group will test one electrolyte solution and put their data in a shared data table. Students will wear proper lab attire and PPE throughout the experiment • Motivational Hook Questions: By yourself, write down three questions you have about batteries. Then get with your partner(s) and decide on two questions you would like to pursue for this activity. • "Why do Batteries die?" • "What components of batteries could be changed to increase efficiency?"
Day 2:	• Using a permanent marker (Sharpie) label your beakers "A" and "B". • Have students roll each piece of aluminum foil so the long side of the roll is about 12 in (30 cm). Crumple about 1/4 of one end on each roll. • Place one aluminum foil roll in each container, placing the crumpled end on the bottom of the container. Carefully flatten the rolled part of the foil against the side of each container. • Place a paper cup bottom (or milk cap) on top of the crumpled foil in each container; the aluminum foil column should go up and around the side of the paper cup (or milk cap) • Carefully wind one end of the 12 in (30 cm) piece of copper wire around the top of the foil roll in container A. Make a couple winds with the wire to get a good connection. Leave the other end of the wire free. • Coil about 22-24 in (55-60 cm) of the 31.5 in (80 cm) piece of wire into a ball. Place this ball on top of the paper cup bottom in container B. Make sure the copper wire is not touching the aluminum foil. • Coil about 22-24 in (55-60 cm) of the second 31.5 in (80 cm) piece of wire into a ball. Place this ball on top of the paper cup bottom in container A. Make sure the copper wire is not touching the aluminum foil. • Carefully wind the free end of the third piece of copper wire (the 31.5 in wire in container A) around the top of the foil roll in container B. Again, make a couple winds with the wire to get a good connection. • Testing the Battery. Repeat steps 9–15 for each team. • Connect the free end of the wire from container A to one of the ammeter connections. • Connect the free end of the wire from container B to the other ammeter connection.

	• Obtain an electrolyte solution. RECORD THE ID NUMBER OF YOUR SOLUTION ON YOUR LAB PAPER BEFORE CONTINUING. • Pour about 50 ml of the electrolyte solution into container A and about 50 ml of the same solution into container B. The solution should cover the wire coils in both containers completely; if not, carefully add more of the solution. • Measure the current produced by the battery using a DC ammeter. Have one student from each team record the electrolyte solution ID number and current on the class data sheet. • Before leaving class, discuss the results of this experiment with your partner(s) and determine one element of the batter you would like to change. • Propose your idea to your instructor. Recall that different batteries may have different cathodes, solutions or numbers of cells. • On day 3 your group will bring the necessary supplies to create a new and unique battery system.
Day 3:	• Students will create their modified batteries and record the current, sharing the information with the classroom • Data Table • What changes did you make to your battery system? • Did your changes seem to improve the current in your battery system? Explain why you had the results you did. • What would you have done differently if you were to redesign your battery system?

5E Model: *(Engage, Explore, Explain, Evaluate, Elaborate)*

- Engage: The *Before* section of the Lesson Plan. Students will be shown two models and be asked inquiry-based questions. Shown Above.

  Explore: Students will change one aspect of their battery system. The change must be reasonable and approved by the instructor. Example Changes might be a different cathode, anode or electrolyte solution. Some students may wish to add another cell to the series to test the effect. Students will bring their own supplies to make the changes. They may bring a different conductive metal from home or a favorite drink to test. (Data Table Link)

- Explain: Explicit Instruction of Batteries and Electrolytes
- Evaluate: Observation of the student's battery system.
- Elaborate: Discussion after activities over redesigns of battery systems

Extensions/Differentiation:

This activity has a guided portion and an inquiry portion. This activity is not about success or failure but learning. Students may very well produce a less efficient battery system in the second portion of the lab but it is a great learning experience.