Electrochemistry

Next Generation Science Standards

NGSS Science and Engineering Practices:

- ☐ Asking questions and defining problems
- ☐ Developing and using models
- ☑ Planning and carrying out investigations
- ☑ Analyzing and interpreting data
- ☐ Using mathematics and computational thinking
- ☑ Constructing explanations and designing solutions
- ☐ Engaging in argument from evidence
- ☑ Obtaining, evaluating, and communicating information

NGSS Cross-cutting Concepts:

- ☐ Patterns
- ☑ Cause and effect
- ☐ Scale, proportion, and quantity
- ☐ Systems and system models
- ☑ Energy and matter
- ☐ Structure and function
- ☐ Stability and change

NGSS Disciplinary Core Ideas:

- ☑ PS2.A: Forces and Motion
- ☑ PS3.B: Conservation of Energy and Energy Transfer

Initial Prep Time

Approx. 5 min. per apparatus, plus time to heat water to 90°C.

Lesson Time

1 – 2 class periods, depending on experiments completed

Assembly Requirements

- Hot plate, or other heating apparatus

Materials (for each lab group):

- Horizon Electric Mobility Experiment Set
- Distilled water
- Table salt
- Celsius thermometer
- Various Beakers
- Balance
- Horizon Renewable Energy Monitor or multimeter (optional)

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Lab Setup

- Students will need the chassis, red and black wires, the salt water battery (white bottom and blue top), and syringe to assemble the salt water battery.
- The bulk of preparation will be in making a large batch of heated water. Each lab group will need samples of about 25mL per experiment, so plan accordingly.
- Initial concentration should be 15mg salt/25mL water. Initial solution temperature should be about 90ºC (194ºF).
- If you want to perform the Concentration experiment, students will need balances to measure out grams of salt and graduated cylinders for measuring out water.
- If you're performing the Temperature experiment, you'll need multiple hot plates or other heating device with adjustable temperature, or multiple beakers and thermometers that can be left off of the heat for different lengths of time to create batches at gradually lower temperatures.
- Lab includes small parts that can go missing easily. Set up a resource area for each lab table or for the entire class to minimize lost pieces.
- If you don't have access to a multimeter or Horizon Renewable Energy Monitor, omit the Measurements section of this activity.

Safety

- Hot water can easily cause burns. Students should wear protective gloves or mitts when handling containers of hot water.
- Safety goggles should be worn at all times.

Notes on the Salt Water Cell:

- The fuel cell and anode should be rinsed out with distilled water between uses.
- White magnesium hydroxide may precipitate on the magnesium anodes, but it can be safely washed off.
- Store the anode and cell separately in a dry place.

Common Problems

- If all your wired connections are good and there's still no electricity, try cleaning the magnesium plate.

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Goals

- Assemble and run a salt water battery
- Maximize the generated electric current
- Make calculations based on data

Background

Electrochemistry is a branch of scientific study that has been around for hundreds of years. Almost as soon as experiments with electricity were developed, it was recognized that there were chemical processes that could produce an electric current.

Now we know that electrochemistry is involved in your own brain, and that the thoughts, feelings, and memories you have would not be possible without a near-constant movement of electrically charged ions in and around the cells of your brain.

Electrochemistry is closely related to redox reactions. All electrochemical reactions involve two electrodes: an anode and a cathode. The anode is defined as the electrode where oxidation occurs and the cathode is the electrode where the reduction takes place. So the anode is negatively charged and the cathode is positive.

In our battery, the anode is made of magnesium, while the cathode is actually the air around it, so the overall reaction is:

$$2Mg + O_2 + H_2O \rightarrow Mg(OH)_2$$

Between the two electrodes is an electrolytic solution of salt water. Can we change the electrical output of the battery simply by changing the solution?

During this activity, you will use different solutions of salt in water determine the effects on the battery's electric current.

Procedure

1. Get salt water solution from your teacher and put it in the graduated cylinder. Make sure to get at least 25mL. And be careful, it's hot!
2. Using the syringe, transfer 15mL of the salt water solution into the bottom of your battery.
3. Snap the blue top of the battery onto the white bottom.
4. Attach one red wire to two red plugs on the left and right sides of the battery at the back.
5. Connect the wires from the motor to the red and black plugs nearest to them on the front of the frame.
6. Connect the loose wires from the battery to the other plugs on the front of the frame.
7. Use the stopwatch to time how long your car takes to complete the track. Repeat and record your results in the table below.
8. When you're finished with the salt water battery, rinse the top and bottom with distilled water.

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Observations

Data Table

Trial	Time (sec):	Observations:
1		
2		
3		

Experimentation

1. Run your battery like you did in the Procedure section, but this time measure out different volumes of salt water to see what happens to the motor. Record your observations below.

Volume (mL):	Time (sec):	Observations:
5		
7		
10		
12		
15		
18		

2. How can you maximize the amount of electric current generated by your battery? Using the volume that worked best in the previous experiment, work with your group to think of ways that you can make the motor move faster by generating more electricity. Change the characteristics you think might have an effect and record your observations below:

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Trial:	Time (sec)	Observations:
1		
2		
3		
4		
5		
6		
7		
8		

Some examples of things students could try: different concentrations of salt water, different solution temperatures, different wires, different air temperatures, different air humidity.

Measurement

For this section, you will need a multimeter or the Horizon Renewable Energy Monitor. For an introduction to using a multimeter, click here.

1. 1.Raise the front wheels off the ground and measure the current in Amps and the voltage in Volts while running the battery with different volumes of salt water. Record your answers below:

Volume (mL):	Current (A):	Voltage (V):
5		
7		
10		
12		
15		
18		

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2. Voltage is equal to the current multiplied by the resistance (V = IR), so according to your data what is the resistance of the fan motor?

(Answers in this section will vary, but check that they are within reason, i.e. not >1A.)

Resistance: ____________ Ω

3. Construct an explanation of what you observed as you tested salt water solutions of different volumes.

Analysis

1. Make a scientific claim about what you observed while running your battery.

Claim should reference the cell's volume or current output.
Example: "The ideal amount of salt water solution for the salt water battery is 15mL."

2. What evidence do you have to back up your scientific claim?

Evidence should cite data in Observations and/or Experimentation sections.
Example: "The biggest current we measured for 15mL of solution was 0.195 Amps. At 18 mL, it was 0.167 Amps and at 12 mL it was 0.152 Amps."

3. What reasoning did you use to support your claim?

Reasoning can draw from Background section and/or other materials used in class.
Example: "We know that a larger current indicates that the battery is operating more efficiently."

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4. Design an experiment that would determine the effect of the size of the anode on the performance of the battery. Describe your experiment below:

Many answers are acceptable, but students should describe how they would change the size of the anode and measure the resulting current. There should be clear control and experimental groups in the description.

Conclusions

1. Based on your observations, what is the relationship between the volume of the salt water solution and the amount of electricity generated by the battery?

Students should note the direct relationship between the temperature and the current generated.

2. What other factors did you identify that affected the output of the battery?

Answers will vary based on students' choices in the Experimentation section.

3. Based on your experiments, what would be the best possible conditions for maximizing the electrical output of the battery?

Answers will vary based on students' choices in the Experimentation section.