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:

- ☑ PS1.A: Structure and Properties of Matter
- ☑ PS3.A: Definitions of Energy

Initial Prep Time

Approx. 5-10 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 Salt Water Fuel Cell Science Kit
- Distilled water
- Table salt
- Celsius thermometer
- Various Beakers
- Balance
- Horizon Renewable Energy Monitor or multimeter (optional)

Electrochemistry

Lab Setup

- Before the lab starts, you should assemble the fan motor, and attach the bottom of the salt water cell to its base.
- The bulk of preparation will be in making a large batch of heated salt 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're performing the Volume experiment, students can measure it themselves, so you don't need to prepare anything extra.
- 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 Fuel Cell Science Kit:

- 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 fuel cell separately in a dry place.

Common Problems

- If all your connections are good and there's still no electricity, try cleaning the magnesium plate.
- The fan motor sometimes needs a quick tap or flick to get it to start spinning.

Electrochemistry

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. Look at the two parts of the battery and how they fit one inside the other. Does it matter which way you put one inside the other? How will you get them apart once you put them together?
2. The large flat piece with the blue top is the anode for our experiment. Electrons will be flowing out from the anode into a wire once you start the battery. Where would you attach a wire on the anode? What color of wire do you think you should you use?
3. Measure out 15 mL of salt water using the graduated cylinder and use the syringe to transfer it to the bottom part of the battery. Why do you think we don't fill it up all the way?
4. Take your anode and clip it into the bottom part of the battery. Where should you put wires to let electrons start flowing through your fuel cell?
5. You have two red wires, but only one needs to connect the battery to the fan motor. Where would you put the other red wire?

Electrochemistry

6. Attach the black and one red wire to the fan. Attach the other red wire to two red sockets on the front and back sides of the anode. This should start the fan running. Write down anything you observe in the Observations section below.

7. Attach the black and one red wire to the fan. Attach the other red wire to two red sockets on the front and back sides of the anode. This should start the fan running. Write down anything you observe in the Observations section below.

Observations

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:

Electrochemistry

Trial:	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. 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		

Electrochemistry

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."

Electrochemistry

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.