Solution Concentrations

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 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

- Create solutions of different concentrations
- Use solutions to run a salt water battery
- Make calculations based on solution data

Background

Combining two substances doesn't have to result in a chemical reaction. It's possible to mix substances and have them form a mixture instead of a compound. Mixtures are classified based on how the substances interact when mixed together.

Heterogeneous mixtures still have different parts visible (like if you shake up oil and vinegar salad dressing) while homogeneous mixtures appear to be the same throughout (like air, which is a mixture of nitrogen, oxygen, carbon dioxide, and trace gases).

Solutions are a special type of homogeneous mixture where the particles of the substance being dissolved are so small that they can't be separated from the mixture by straining or centrifuging. Salt in water is a perfect example: once the salt has dissolved in the water, it can't be removed unless the water is evaporated.

Dissolved salt splits into sodium (Na^+) and chloride (Cl^-) ions. The presence of these ions in the water makes it easier for an electric current to flow. This allows us to generate electricity by pumping electrons from the magnesium anode to the cathode (which is actually the air) through the wires, just like a battery. If you don't remember what anodes and cathodes are, read more about electrodes in Introduction to Batteries.

The concentration of a solution can be expressed as a percentage ratio (mass of solute/volume of solvent) or as a molar ratio such as molarity (moles of solute/volume of solvent) or molality (moles of solute/mass of solvent).

During this activity, you will use a solution of salt in water to run a battery and generate an 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. Prepare solutions of salt water according to the following concentrations. Record how much salt you used in each concentration below:

Concentration:	g NaCL:	mL H2O:
4%	1	25mL
8%	2	25mL
12%	3	25mL
16%	4	25mL
20%	5	25mL

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2. Using the different concentrations of salt water solution, use the battery to power the motor as in the Procedure section. Observe what happens each time and record your results below. Be sure to rinse out the salt water from the battery after each trial.

Concentration:	Time (sec):	Observations:
4%		
8%		
12%		
16%		
20%		

3. Using salt water of different temperature, run the battery like you did in the Procedure section, using the same concentration each time. Write your observations below.

Temperature (°C):	Time (sec):	Observations:

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. Raise the front wheels off the ground and measure the current in amps and the voltage in volts while running the battery at different concentrations of salt. Record your answers below:

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Concentration:	Current (A):	Voltage (V):
4%		
8%		
12%		
16%		
20%		

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. Measure the current in Amps and the voltage in Volts while running the battery with different temperatures of salt water. Record your answers below:

Temperature (°C):	Time (sec):	Observations:

4. Construct an explanation of what you observed as you tested salt water solutions of different temperatures.

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Analysis

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

Claim should reference the data from the concentration or temperature experiment.
Example: "The best concentration of the salt water solution is between 16 and 20%."

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

Evidence should cite data in Observations and/or Experimentation sections.
Example: "The current we measured for 20% was 0.195 Amps, while the current at 16% was 0.196 Amps and the current at 12% was 0.174 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: "The highest current output must occur when the battery is running most efficiently."

4. Design an experiment that would determine the volume of salt water solution that would produce the most electric current. Describe your experiment below:

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

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Conclusions

1. Express the concentrations of salt water solution you measured as molar and molal solutions:

Concentration:	Molarity (mol/L):	Molality (mol/kg):
4%		
8%		
12%		
16%		
20%		

Since 1L H2O has a mass of 1kg, molarity and molality should be the same.

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

Students should note that there is a point at which added salt does nothing to affect the generation of electricity and speculate as to why that might be.

3. Based on your observations, what is the relationship between the temperature 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.