Electrochemical Chameleon Student Handout

Overview

In order to limit the negative impacts of climate change, **decarbonization** (elimination of greenhouse gas emitting processes) of the **electric grid** (the network that transports electricity from power generation facilities to consumers) is necessary. **Clean energy** technologies (systems that generate electricity from sources that are constantly replaced and do not generate greenhouse gasses) provide a solution to this issue. However, most clean energy technologies are **intermittent**, meaning they only produce electricity at certain times. One way to overcome this challenge is to store the extra electrical energy from clean energy sources as **chemical energy**, or energy that is stored by making or breaking chemical bonds. Common methods of doing this are by using large batteries or producing hydrogen and oxygen gas from water in a process known as electrolysis. These gasses can be burned, or used in a **hydrogen fuel cell**, a device that uses the reaction between hydrogen and oxygen gas to produce electricity, to recover the stored energy.

In this lab, we will use pH measurements to understand the reactions occurring during water splitting. One way to track the progress of a chemical reaction is by monitoring the pH (the acidity or basicity) of the reaction solution. In this lab, you will begin by creating a range of pH reference solutions, and then use these solutions to understand the results of your experiment with storing electrical energy as chemical energy by splitting water into its component parts, hydrogen and oxygen.

Hazards:

Vinegar (an acid) and ammonia (a base) can irritate the skin and eyes. Avoid direct contact with skin and eyes. In the event of direct contact, flush with water for 15 minutes. Natural anthocyanin dyes can stain clothing and skin. Avoid spilling anthocyanin dyes on clothing and skin. H_2 and O_2 gasses are flammable, keep the evolved gasses away from sparks and fire.

Protocol for pH indicator Lab:

In this lab, you will follow the procedure below to set up your pH reference solutions, and then use these solutions to understand the results of the electrolysis experiment coming up next.

1. Take a moment to find the following materials on the table and observe them. Do you think it will be acidic or alkali/basic? Write your predictions in the table below:

Antacid	Lemon Juice	Baking Soda	Tap water	Sprite	Baking Powder	Vinegar	Ammonia

Now, one person on the team will be the recorder and write down all observations during the experiment in this worksheet. The other person will prepare the solutions. Alternate roles with each solution.

2. To vial #1 add a few granules of antacid and record your observations of the solution:

3. Switch roles. To vial 2 add a few drops of lemon juice (a stronger acid/base! Avoid direct contact with skin and eyes!) and record your observations:

4. Switch roles. To vial 3 add a few granules of baking soda and record your observations:

5. Switch roles. To vial 4 add a few drops of tap water and record your observations:

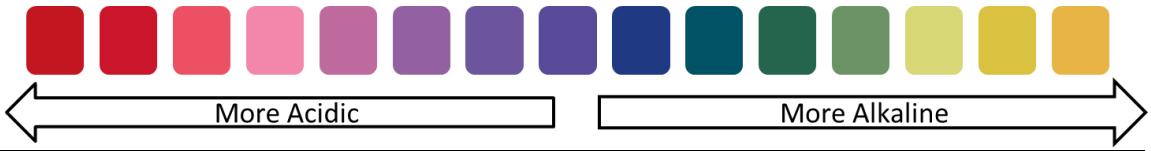
6. Switch roles. To vial 5 add a few drops of Sprite and record your observations:

7. Switch roles. To vial 6 add a few granules of baking powder and record your observations:

8. Switch roles. To vial 7 add a few drops of vinegar (a stronger acid/base! Avoid direct contact with skin and eyes!). Record your observations:

9. Switch roles again. To vial 8 add a few drops of Ammonia (a stronger acid/base! Avoid direct contact with skin and eyes!). Record your observations:

10. From left to right, arrange your vials from most acidic to most alkaline basic! Were your predictions in question 1 correct? Fill your results in the table below:



Vial #								
Solution Name								

Protocol for Electrolysis Lab:

Now you will conduct an electrolysis experiment! You will split water into hydrogen and oxygen, which are clean fuels that can be used to store chemical energy. Additionally, you will use your pH reference solutions to understand the results of your electrolysis experiment. Follow the procedure below to perform water electrolysis.

11. Water electrolysis is converting a water molecule into hydrogen and oxygen gas. Write the chemical equation for this reaction

12. The overall reaction of water electrolysis in question 11 is the result of two half reactions, as shown below. Balance the half reactions and combine them to get the balanced full reaction.

Half Reaction 1: $?H_2O \rightarrow ?O_2 + ?H^+ + ?e^-$
Half Reaction 2: $?H_2O + ?e^- \rightarrow ?H_2 + ?OH^-$
Full Reaction: $?H_2O \rightarrow ?H_2 + ?O_2$

Pour purple pH indicator cabbage juice into your new electrolysis cell until the container is 3/4 of the way full. Insert two plastic pipettes into your electrolysis cell (with the purple pH indicator solution). Extract cabbage juice with your 2 pipettes up to the mark (1.5mL). Without removing the tips of the pipettes from the solution, place each pipette tip over one of the electrodes (thumbtacks) in your electrolysis cell.

13. What do you think you will observe when you connect the battery to your cell? Record your prediction below.

Have one person on the team hold and stabilize the pipettes so that they don't disconnect from the electrodes (thumbtacks). Meanwhile, let the other person place your electrolysis cell (the container) on top of your 9-volt battery so that each battery terminal is touching each thumbtack on the bottom of your cell.

14. What do you observe? Was your prediction in question 13 correct?

15. Now we will add Epson salt to the solution and repeat the experiment. What do you think you will observe when you connect the battery to your cell when Epsom Salt is added?

16. Add Epson salt to the solution and repeat the experiment. Record your observations here. Was this different from what you observed without the salt? If it was, why?

17. What happened at each battery terminal? Was the solution acidic, basic, or neutral?

18. How much solution was left in each of your pipettes when your experiment was finished? What does this mean about the volume of gas that was produced at each terminal?

19. How does this confirm that water has the chemical formula H_2O?

20. If you are using the extension, go to step 1 there. Otherwise, dispose of your solutions down the drain. Rinse out and return your glassware

Conclusion

1. What insights did you gain about the splitting of water?

2. What most surprised you about today's activity?

3. How did you use pH to "observe" water electrolysis?

4. Why is hydrogen being considered as a way to contribute to the mitigation of climate change?

5. Can you think of any challenges of using hydrogen for this purpose?