Engineering Tomorrow

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Green Hydrogen Lab Worksheet

Here you will find the instructions to create your own electrolytic cell that produces green hydrogen in just a few hours! Follow all the instructions for this worksheet and fill in the blanks as you go.

INTRODUCTION:

Carbon dioxide levels have fluctuated for millions of years, but the level of carbon dioxide in the atmosphere has never been higher than it is now. This is leading to:

- **Hotter Temperatures:** Rising temperatures cause heat-related illnesses and increase wildfire frequencies
- **More Severe Storms:** Changing temperatures impact rainfall, which leads to more severe/frequent storms and catastrophic floods/landslides
- **Rising Sea Levels:** As water temperature increases and ice caps melt, water levels rise endangering coastal communities and marine life
- **Increased Health Risks:** Worsening air and water quality increases the spread of certain diseases

Answer Me! In your opinion, who might be most affected by the effects of a warming climate?

Engineers and scientists are looking for ways to *decarbonize* processes . Green hydrogen is one of these processes.

Answer Me! What is your definition of decarbonization?

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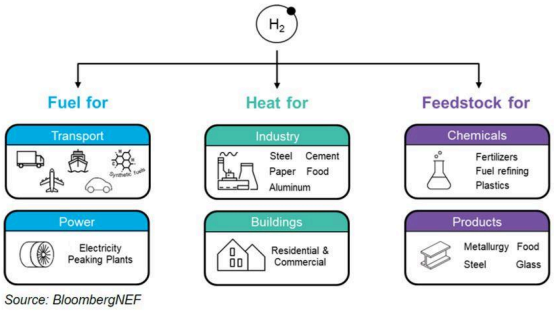
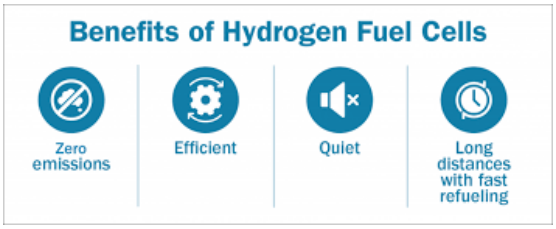
What is Green Hydrogen?

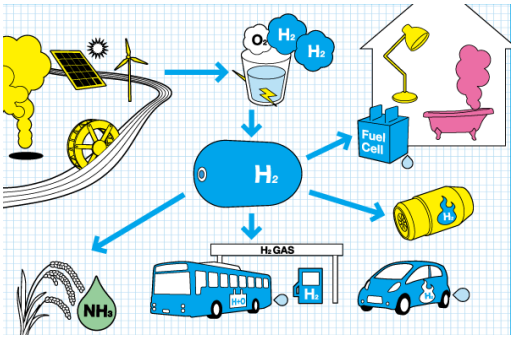
Green hydrogen is a renewable energy source produced entirely by water! It is produced entirely by renewable energy sources and creates little to no emissions. Hydrogen has so many different uses in various fields!





Answer Me! What use of hydrogen is most surprising to you?

Let's think and discuss! Take some time to discuss with your group after answering these questions. What industry do you think would most benefit from green hydrogen? What are some pros and cons of using green hydrogen as a fuel source?



What is an Electrolytic cell?

Electrolytic cells split water into oxygen and hydrogen molecules that are then used to generate power.

$$2H_2O \rightarrow 2H_2 + O_2$$

STEP ONE: LEARN

Let's learn how to understand oxidation states in redox reactions! The element that is **Oxidized** in a redox reaction loses electrons, whereas the element that is **Reduced** gains electrons.

Tip: An easy way to remember which term means loss of electrons and which term means gain, use the phrase **OIL RIG**, which means "**O**xidation **I**s **L**oss, **R**eduction **I**s **G**ain" (of electrons).

$$Zn(s) + 2\,H^{+}(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

Rules for Oxidation States	Determining Oxidized and Reduced Species
Reactants: • Zn has an oxidation state of 0 since it is an individual atom • H^+ has an oxidation state of +1 since it is an ion **Products:** • Zn^{2+} has an oxidation state of 2+ • H_2 has an oxidation state of 0 ○ Note: diatomic atoms do not count as compounds, so H will not have an oxidation state of +1	**REDUCED:** Hydrogen is reduced as it goes from an oxidation state of +1 to an oxidation state of 0 **OXIDIZED:** Zinc is oxidized as it goes from an oxidation state of 0 to an oxidation state of +2 We can now split the reaction into reduced and oxidized.

Now let's split this reaction into a half reaction! One half represents a species being oxidized while the other half represents the other species being oxidized.

REDUCING REACTION:
Without Balancing with Electrons:

$$H^+ \rightarrow H_2$$

After Balancing with Electrons:

$$2H^+ + 2e^- \rightarrow H_2$$

OXIDIZING REACTION:
Without Balancing with Electrons:

$$Zn \rightarrow Zn^{2+}$$

After Balancing with Electrons:

$$Zn \rightarrow Zn^{2+} + 2e^-$$

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PUTTING IT TOGETHER: Can you find the half-reaction that makes hydrogen gas?

$$2H_2O \rightarrow 2H_2 + O_2$$

WHAT IS OXIDIZED AND WHAT IS REDUCED?

WRITE THE EQUATION ASSOCIATED WITH HYDROGEN GAS.

BALANCE WITH ELECTRONS.

HINT:
To maintain oxygen on both sides of the equation, add OH^- to the products side

WHAT YOU WILL NEED:

In your kit, you should see the following materials. You will use the water bottle to create your cell and the straw will help check the hydrogen levels. You will create your power source using the battery.
If you are missing any materials, let your teacher know now.

If you need help getting started, feel free to check out the **ZiroAI Green Hydrogen Coach** or scan the QR code at right.

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STEP TWO: THINK ABOUT THE PROBLEM

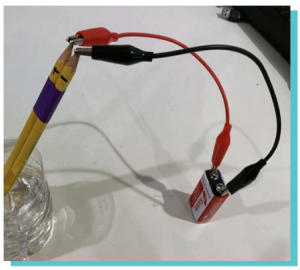
Imagine you are a chemical engineer working on creating a green hydrogen fuel cell. What global issue are you trying to solve? Why is this important? .

Answer Me!

In working on your project you will be splitting up the members of your team into designated roles. Although **you should ALL work together on ALL aspects of your project** here are the roles and responsibilities that we suggest to help keep your group organized.

CONTAINER PREPARER
This person will be in charg of preparing the water bottle and straw.

SOLUTION MANAGER
This person will be in cha of filling the water bott and straw with water, a potentially preparing th saltwater solution.



WIRE SPECIALIST
This person will be in charge of preparing the pencils, and making the connection between the pencils, wires, and battery.

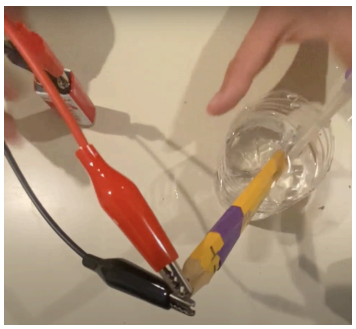
STEP THREE: BUILD

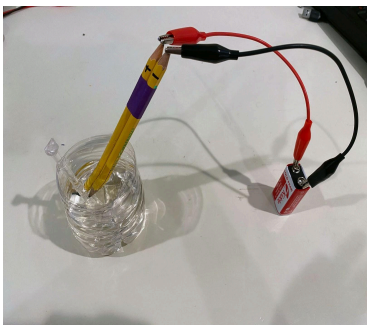
Follow the steps below to build your electrolytic cell!

1. Sharpen both ends of the pencil so that each end is identical and there is graphite visible on both ends.
2. Cut the water bottle about halfway down so that there is a large opening in the bottle.
3. Seal one end of the straw so that one end is completely sealed and no water or gas can get out. **Tip**: fold one end then glue or tape it to get a good seal.

4. Cut a small hole close to the open end of the straw so that the pencil can fit in.

5. Fill the bottle about ½ full and the straw all the way full of water. Make sure you are holding the hole you cut in the straw so no water leaks. Then, place the straw into the bottle without spilling any water. **Optional**: hot glue or tape the straw to the side of the cup so it doesn't fall (be sure the hole is facing out).
6. Tape the pencils together and place the pencils in the water. Be sure to place the "cathode" pencil inside the straw. **Optional**: mark one pencil with a "+" and the other with a "-" to keep track of which is the cathode (connected to the negative terminal of the battery) and which is the anode.
7. Connect the Jumper Cables to the pencils and to the battery. Be sure to connect the correct wires to the correct terminals of the battery and pencils!
8. Now you are done with the setup of the cell! Keep track of the volume of hydrogen gas by checking the level of gas in the straw!





*If you need more help, scan the QR code or click on this **link** to watch a video of the electrolytic cell setup process!*

LETS SEE!

Insert a picture of your design here or a drawing!

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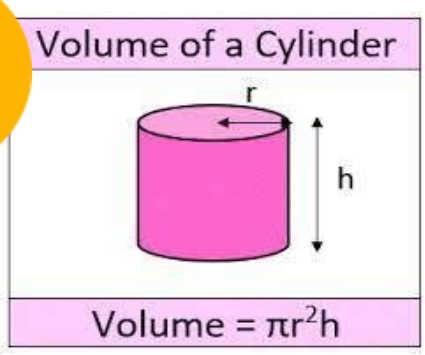
STEP FOUR: TEST

Measure the height of the hydrogen in your straw and the cross-sectional area of the straw. Use this data to calculate the volume of the hydrogen produced and record it in the table below!
Remember: Area = πr^2

Change in height of gas in straw, **h** (in mm)	
Radius of straw, diameter ÷ 2, **r** (in mm)	
Cross-sectional area (mm^2)	
Volume of hydrogen gas (mm^3)	
Volume of hydrogen gas (ml) = $mm^3/1000$	

Measure the height of the gas before and after, then find the difference!



STEP FIVE: ANALYZE

Answer Me! Where did you notice bubbles forming in your cell? Why do you think this occurred?

DISCUSS!

Answer Me: *If you used salt water:* Did you notice a certain smell coming from your cell?

Answer Me: I*f you used tap water:* Could we alter this lab to collect oxygen gas as well? How would we do that?

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STEP SIX: RESEARCH AND REFLECT

Answer Me! What are ways we can make our cell more efficient? Is there anything you would change in the design process? Feel free to do additional research to help with your answer!

STEP SEVEN: STUDENT EXIT SURVEY

Once you've finished the lab, please complete the student exit survey to share your feedback.

ADDITIONAL RESOURCES

If you have any additional questions pertaining to this lab, refer to the ZiroAI Green Hydrogen Coach for more details.