

## West Side Science Club – Event 21 – Hydrogen generation

### Original Presentation (scheduled)

Date: 18 January 2013  
Time: 10 am to 12 pm  
Site: West Side Science Club

### Brief Description

After introducing the idea of fuel cells as a battery that operates using hydrogen we will then go into two types of methods for generating hydrogen: chemical methods using aluminum foil or pellets, and then electrochemical methods using an electrolysis cell. Once the hydrogen is generated we can qualitatively show how hydrogen stores energy through combusting the hydrogen and also passing it through a fuel cell to make electricity.

We will showcase two chemical methods to generate hydrogen, including the use of aluminum foil and sodium hydroxide and the use of a eutectic gallium aluminum mixture and tap water. We will be using a fuel cell kit to show how water can be split into hydrogen and oxygen using electricity, and then run back through a fuel cell to drive a motor. The materials will be coming from Caltech for this session.

### Big Questions

- These questions are meant to frame the day's event and might be written on the chalkboard

(1) What is hydrogen? Why is it useful?

(2) What some ways you can make hydrogen?

Words of the Day: hydrogen, fuel, solar energy

### Concepts

- Concepts to cover from the "Work of CCI Solar" Mind Map: Reactions- oxidation/reduction, acid/base, yield, rate, starting materials, products; Social Aspects- climate change, greenhouse gases, global energy demand, fossil fuels, renewable vs nonrenewable energy; Energy- forms, storage, conversions.

### Motivation for this Activity

This activity is a kick-start for following five lessons. It mainly focuses on how hydrogen as a fuel can be generated. It precedes the discussion of how energy can be storage and how to use renewal energy to generate hydrogen as energy-storage media.

### Lesson Plan

#### *Student Objectives*

- Explore how to generate hydrogen
- Explain the reactivity of hydrogen, as well as demonstrate the energy storage in hydrogen bonds and the reaction product, water
- Explain reaction of metal with water for hydrogen generation

- Review electrochemical water splitting and product ratio,  $H_2(g) : O_2(g) = 2 : 1$

### Schedule/Agenda

- Review: Plastics Event #16 – #19 (“Thermoplastics and scar stuff”, “Recycling plastic” and “Bioplastic”) and Caltech Visit (Ben, 5 min)
- Introduction to hydrogen, fuel cells, and fuel cell-driven cars (Ben, 5 min)
- Hydrogen, hydrogen reactions (Shu, 5 min)
  - Recap the chemical formula of hydrogen
  - Recap the reactivity of hydrogen, the reaction products
- Chemical means of hydrogen generation (Shu demo outside the classroom):
  - Activity #1: Use aluminum food wrap and water vs. sodium hydroxide to make hydrogen (10 - 15 min). Aluminum does not react with water by itself.
  - Activity #2: Use aluminum dissolved in liquid gallium to make hydrogen from tap water (25-30 min)
- Quantitative, electrochemical hydrogen generation (Shu demo with help of mentors):
  - Activity #3: Use a reversible fuel cell to split water into hydrogen and oxygen at a ratio of 2:1, and briefly show hydrogen can be used to convert back into electricity and drive heavy loads like motors
  - Activity #4: Explore hydrogen generation using solar panels, power supplies, and battery packs
- Wrap Up and Summarize Findings and Unusual Discoveries (10-15 min)

### Materials

#### Activity #1 and 2: Gallium and Aluminum H<sub>2</sub> Generation

- Aluminum foil
- 1 M sodium hydroxide solution
- Glass wares
- Balloons
- DI water
- Cups
- Hotplate
- 99.9% gallium
- Al pellets
- Sand paper
- Stir bar

#### Activity #3 and 4: Fuel cell electrolysis

- Fuel cell/water electrolysis educational kits, 2 or 3 (reversible fuel cells, H<sub>2</sub>/O<sub>2</sub> tanks)
- Solar panels
- Electrical wires
- Multimeters, 2 or 3
- Battery packs, provide 6V
- Power supply

## Safety

- Students must wear their eye protection and gloves to practice good safety habits for experimental work
- While many materials can be found in households, the demos are not recommended to be performed at home
- Sodium hydroxide is a strong base and can cause burns. Everyone needs to wear gloves and goggles during the demonstrations
- Hydrogen are extremely flammable, and safety precautions need to be emphasized repeatedly

### **Activity #1: Making hydrogen from aluminum foil and sodium hydroxide (strong base)**

1. Add solid sodium hydroxide pellets to a flask of water on a stirrer hot plate. Add about 100g of sodium hydroxide to a liter of water for making this stock solution.
2. Once the pellets dissolve the hot plate can be turned off.
3. Tear off sheets of aluminum foil and crumple them into balls.
4. Add the aluminum into the flask. Only a few grams at a time.
5. The solution will be reacting vigorously, generating aluminum hydroxide and hydrogen gas. At this time put a balloon over the top of the flask to gather the hydrogen gas for later combustion.

### Facilitation/Concept Questions

- What happened to the aluminum in the solution?
- Where did the hydrogen gas come from in this reaction?
- What had to be added to the water to make the aluminum react?

### **Activity #2: Making hydrogen from aluminum pellets, gallium and tap water**

1. (Prepared at the very beginning) gallium melt by heating up solid gallium at 50 °C.
2. Sand paper an Al pallet and immediately throw it into the gallium melt
3. Heat up the mixture while stirring it
4. After 30 min, the Al is completely dissolved
5. Pour tap water on the Al-Ga mixture, and then hydrogen bubbles will form immediately
6. Use a balloon to collect hydrogen gas
7. When full, take balloon outside and use a long stick with a match at the end to ignite the balloon, away from any people. Compare this to igniting a balloon filled with regular air.

### Facilitation Questions and Advice to Mentors

- What happened to the aluminum metal in gallium?
- Looking at a periodic table what is the same about gallium and aluminum?
- What happens to the gallium when the water is poured onto the solution?
- What was reacting to make hydrogen gas? How can we tell?
- Why does aluminum not normally react with water? What could the gallium have done to make this reaction possible?

### **Activities #3 and 4: Making hydrogen by electrolysis of water using a reversible fuel cell**

1. Distribute water electrolysis kits among groups of kids
2. Fill DI water into fuel cell, hydrogen and oxygen storage tank

3. Connect DC power sources to the reversible fuel cell
4. Watch hydrogen and oxygen bubble form and fill up the tanks
5. Record the volume ratio of generated hydrogen and oxygen
6. Try to replace the power source with the following: solar panels, battery packs.

### Possible Facilitation/Concept Questions

- Why is the volume of hydrogen generated twice that of the oxygen in the fuel cells?
- How is hydrogen made in the fuel cell?
- Where does the hydrogen come from in this type of fuel cell?
- What happens to the gas tanks when using the fuel cell?
- Is the water a source of the electricity in the fuel cell?

### Wrap Up

- Students should share their experiences of how easy/hard it was to generate hydrogen.
- Discuss why hydrogen is good to use as a fuel compared to what we currently use as fuels

### References

<http://www.youtube.com/watch?v=VcrmshRWO5Q>