### Required Training

UC Lab Safety Fundamentals

### Required PPE

- **Flame-resistant lab coat**, safety glasses/goggles,
- nitrile gloves

### Performers Required: 1

### Equipment

- House built set-up
- Metal spoon
- BBQ-style butane lighter (≥ 6" long)

### Chemicals

- Sulfuric acid (H2SO4)
- Glycerine
- Dawn dish soap

### Procedure:

1. Ensure there is enough bubble solution in the set up, approx 200 mL
   70 mL glycerine, 150 mL Dawn Dish Soap, 780 mL DI Water (1 L total).

2. 10-30 minutes prior to the start of the demonstration prime the system by turning it on. Dispose of the initial bubbles filled with air. The system is primed when oxygen and hydrogen bubbles are produce, i.e. the bubbles pop.

3. To test the bubbles, scoop them from the surface of bubble solution with the metal spoon. Do not scoop up any bubble solution.

4. While holding the spoon behind the protective plexiglass barrier, ignite it using the butane lighter. When you hear a pop, the bubbles are filled with hydrogen.

5. Turn off the system until you are ready.

### Clean-up: None required.

### Hazards: Sulfuric acid is strongly oxidizing and corrosive, and will cause immediate chemical burns on contact. The combustion produces heat, be careful when handling the spoon after repeated use. Keep flammable materials away when performing the demonstration.

### Principle: The system contains a platinum electrode submerged in a 1 M sulfuric acid electrolyte solution. Gas is
produced by providing a potential to split water (H2O) into hydrogen (H2) and oxygen (O2). The following shows the total reaction at the anode and the cathode along with voltages:

Anode (oxidation) \(2 \text{H}_2\text{O}(l) \rightarrow \text{O}_2(g) + 4\text{H}^+(aq) + 4\text{e}^- \quad \text{E}_0^{\text{ox}} = -1.23 \text{ V} \quad (\text{E}_0^{\text{red}} = 1.23)\)

Cathode (reduction): \(2\text{H}^+(aq) + 2\text{e}^- \rightarrow \text{H}_2(g) \quad \text{E}_0^{\text{red}} = 0.00 \text{ V}\)

H2 and O2 bubbles are formed as the system pumps the gases through the bubble solution. When ignited, hydrogen gas combines with oxygen gas explosively. The ignition temperature of the reaction is 580-590°C. Water is the product of this exothermic reaction along with 232 kJ. The rapid release of energy causes the surrounding air to expand suddenly, resulting in a sharp pop.

\(2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l)\)

**Notes:** Eventually the electrode and electrolyte solution will need to be replaced. If the transformer is on but no bubbles are being produced this is likely the problem.

**Hazards:**

![Warning](https://via.placeholder.com/150)

DO NOT OVERHEAT THE MACHINE.

The machine cannot be run for the entire class period without overheating; heed the warnings on the machine itself. If you would like less down time in showing your demonstration, you can run the machine shortly before class and it will have a shorter boot-up time. As always, be careful with the demo and report to the dispensary any noticeable wear on the machine. There is an electrical component to this demonstration, so be careful not to electrocute yourself or viewers.