

3.5) INSTRUCTOR'S GUIDE FUEL CELL DYNAMICS

Overview:

Part A: Coil the catalytic electrodes around a thin nail before the lab. The coiled shape increases the surface area of wire inside the solution, thereby increasing the amount of gas bubbles sticking to the electrode.

The following results were obtained using two 18-in. platinum-coated nickel electrodes: Voltage stayed between 0.8 and 1.5 volts for at least 5 minutes, and the digital watch ran for 1-3 minutes. With the use of gel, the digital watch ran for up to half an hour. This 10-fold increase in running time can be attributed to the gel allowing more gas bubbles to collect around the electrodes under higher pressure.

Part B: It typically takes about 20 minutes to charge a fuel cell and 40 minutes to discharge, so you might have to divide this procedure over two days if you have only a one-period block of time. Fuel cell charging efficiency is usually between 20% and 30%. This compares poorly with the 60-70% efficiency of a lead-acid battery.

Unlike Lab 3-5, this lab cannot be completed without the use of an auxiliary cable and 9-volt battery because most DC wattmeters need at least 4 volts to light up the digital screen (most inexpensive fuel cells cannot exceed two volts). Guidelines for the use of the auxiliary cable can be found in the instructor's guide to Lab 3-5.

Answers to Questions: 1) Platinum is a catalyst that speeds up chemical reactions. In the absence of a catalyst the reaction would be so slow that it would not provide enough current to run a digital watch or an electric motor. 2) The digital watch runs for 1-3 minutes. If you use agar gel, it may run for half an hour. 3) The voltage drops because the energy source is being removed when the hydrogen and oxygen bubbles lose contact with the wires. 4) This increase the time because it allows more hydrogen and oxygen to make contact with the wires. 5) Answers may vary. The efficiency is usually 20-30%. This is less than half the efficiency of a lead acid battery. 6) Answers may vary. At the very least, the hydrogen will need to be compressed. This would require an additional energy input.

Logistics: If you only have one wattmeter for the whole class, you can have pairs of students take turns setting up the apparatus. If one pair sets it up for charging and another pair sets it up for draining, you will end up involving four students for each battery trial. If this does not cover your whole class, you may consider having those not directly involved in setting up the apparatus take turns reading the meter.

Degree of Difficulty: 2—This lab is fairly easy to execute, but it involves significantly more assembly and rehearsal than Lab 3-5.

Product Guidelines: With the exception of the DC watt meter and platinum-coated wire, most items in the lab can be purchased at a hardware store or electronics supply. The platinum-coated nickel wire (diameter 0.011 inches) was purchased online from Scitoys. The fuel cell used in the lab was part of a toy-car kit purchased online from Thames and Kosmos. Replacement fuel cells can be purchased from the same company but do not include fuel tanks or fuel lines. DC watt meters can be purchased from numerous online sources.

To make sure you can record data when voltage is below 4 volts, you will need to buy an auxiliary power cable (Fig. 1). This cable is powered by a 9-volt battery (Fig. 2) and is plugged into the wattmeter (Fig. 3). The auxiliary power connector cable depicted below was purchased online from Powerwerx.

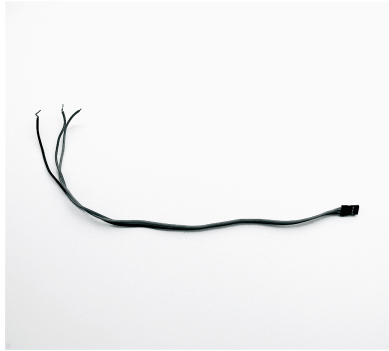


Fig. 1



Fig. 2



Fig. 3

Powerwerx Website: <https://powerwerx.com/watt-meter-analyzer-inline-dc-mc4>

Scitoys Website: https://scitoys.com/fuel_cell.html

Materials:

Part A: Two lengths of coiled catalytic wire (platinum or platinum-plated; 2-3 feet prior to coiling); two 6-inch lengths of coated copper wire; a battery connector; a 150-250-mL beaker; a glass or plastic stirring rod; a 9-volt battery; adhesive tape; sodium sulfate or 1M sulfuric acid; a multimeter; two alligator test leads; and a digital stopwatch (button battery only). *For the optional procedure you need 5 grams of agar and a hot plate.*

Part B: A simple fuel-cell kit (with fuel cell, fuel lines, fuel tanks, and wire leads); distilled water; two AA batteries; a battery holder (for two AA batteries); a battery connector; six alligator clips; a 1.5-volt flashlight bulb with bulb holder; and a DC wattmeter with auxiliary cable and 9-volt battery.