**Fuel Cell**

[Physics 3600 - Advanced Physics Lab - Summer 2021](http://northeastern.edu/heiman/3600/index.html)

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**I. INTRODUCTION**

The objective of this experiment is to study the properties of a solar cell, electrolyzer (EL) and fuel cell (FC). You will (1) study the electrical properties of each component, and (2) measure the conversion efficiency of energy between light, chemical and electrical.

The apparatus is used to convert energy:

(1) from light to electrical energy using a photovoltaic (PV) solar cell;

(2) from electrical to chemical energy using an electrolyzer, by splitting water into hydrogen and oxygen;

(3) from chemical to electrical energy using a hydrogen fuel cell.

**II. APPARATUS**

Hydrogen [fuel](http://www.anp.com.hk/en/ProductDetails_544.html) cell apparatus, H-Tec, [Model T-126](https://h-tec-education.com/tutorial-basic-htec-t126)

Optical Power Meter, Thorlabs, Model PM100D-S121C

2 DVMs; decade resistor (1 Ω - 10 kΩ)

Strong light source (flood light)

2.0 V/2 A power supply, [EasyPlot](file:///C:\Users\Public\EP\Epw32.exe) software

**III. PROCEDURES**

***A. Measure Light Input to the Solar Cell and Determine Efficiency***

1. Set up the circuit to measure the PV power.

2. Place the lamp 40 cm from the PV and aim it so that it shines centered on the PV.

3. Place the head of the ThorLabs power meter at the position of the PV. Set the wavelength to 532 nm.

Active area is 9.5 mm diameter. Divide the meter power by 12.5 to get the true light power.

a. Measure the light ***power*** (p)over each of the 8 PV cells.

b. Compute the average light ***Intensity***(p/area) using the area of the detector.

c. Compute the **total average light Power** on the PV (PL) using the measured area of the PV.

**DO NOT MOVE THE POSITIONS OF THE LAMP AND PV APPARATUS**

4. Measure the output power of the PV.

a. With the lamp on, measure the voltage (V) and current (I) as you vary the resistance from R=0 to ∞. b. Plot I versus V, I(V), as you vary R.

c. Plot the output electrical power (PE= I\*V) versus resistance, P(R) on a log x-axis.

d. Compute the power (energy) conversion efficiency for the PV, ηPV = PE / PL.

YOU WILL **NOT** NEED THE PHOTOVOLTAIC AND LAMP FOR THE REST OF THE EXPERIMENTS.

**You must show the TA your plots at the end of each section before proceeding to the next section.**

***B. Set up Electrolyzer and Fuel Cell***

1. See the Appendix if you need to set up the apparatus with water.

Note that it may already have enough water in the two reservoirs.

2.The Electrolyzer must be filled with water, but the Fuel Cell must **NOT** have water in it.



***C. Efficiency of Electrolyzer***

1. Make sure the tubes connecting the hydrogen and oxygen reservoirs to the Fuel Cell are closed off with the hose clamps.

2. Connect a Power Supply (PS) to the Electrolyzer using an ammeter and voltmeter to measure I and V.

3. Slowly raise the voltage to 2.0 V. **DO NOT EXCEED 2.0 volts or 0.6 amps.**

1. Where does the oxygen go that is produced?
2. Measure the time it takes to collect 5 cm3 of gas in the hydrogen reservoir,

while measuring I and V. Turn down the voltage on the power supply.

1. Compute the energy conversion efficiency for the Electrolyzer, using the time (tE) it takes to

produce VH= 5 cm3 of hydrogen and the input electrical power to the Electrolyzer, PE.

ηE = EHydrogen / EElect = (VH \* HHV) / (PE \* tE),

where HHV is the Higher Heat Value of hydrogen (also called Higher Calorific Value).

***D. Efficiency of Hydrogen Fuel Cell***

1. Collect 20 to 40 cm3 of hydrogen in the right-hand container. **DO NOT EXCEED 2.0 volts or 0.6 amps.**

Make sure that there is no water in FC by following the procedure on the final page.

2. Draw a circuit having an ammeter, variable resistor and Fuel Cell and connect them all in series.

Add a voltmeter across the Fuel Cell.

3. Set up the circuit to measure the power output from the Fuel Cell.

4. Open the two tubes connecting the reservoirs to the Fuel Cell.

a. Measure the I and V as you vary the resistance from R=0 to ∞.

b. Plot I(V) as you vary R.

c. Plot the output electrical power versus resistance, P(R), using a log x-axis.

5. Select a resistance that gives the highest power output.

a. Measure the time (tFC) it takes to use up 5 or 10 cm3 of gas.

b. Compute the energy conversion efficiency for the Fuel Cell, using the time (tFC) it takes to

consume a volume of hydrogen (VH) and the output electrical power PFC.

ηFC = EFC / EHydrogen = (PFC \* tFC ) / (VH \* LHV),

where LHV is the Lower Heat Value of hydrogen (also called Lower Calorific Value).

6. Repeat the last section at different resistances.

a. Measure the energy conversion efficiency for the Fuel Cell at different output powers.

Important - collect data in one day, as data taken during different days may not match.

b. Plot the efficiency as a function of output power, ηFC (P).

**IV. SUMMARY**

a. List all the efficiencies (experimental and expected values) in a table with uncertainties.

b. Discuss the efficiencies and compare to expected values.

c. Identify and discuss the major sources of error in computing each efficiency.

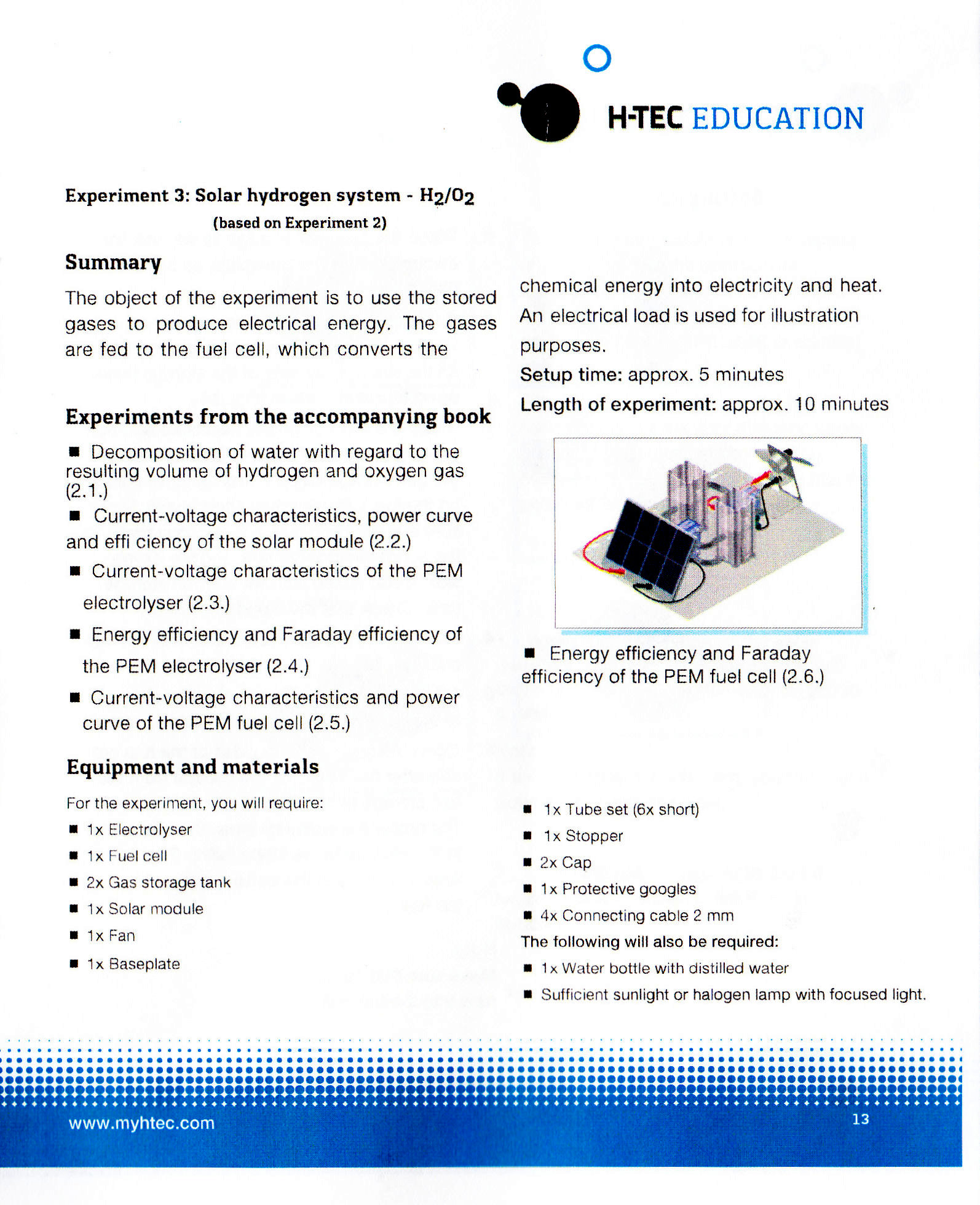
In your Introduction:

a. Describe how the Proton Exchange Membrane (PEM) Electrolyzer works.

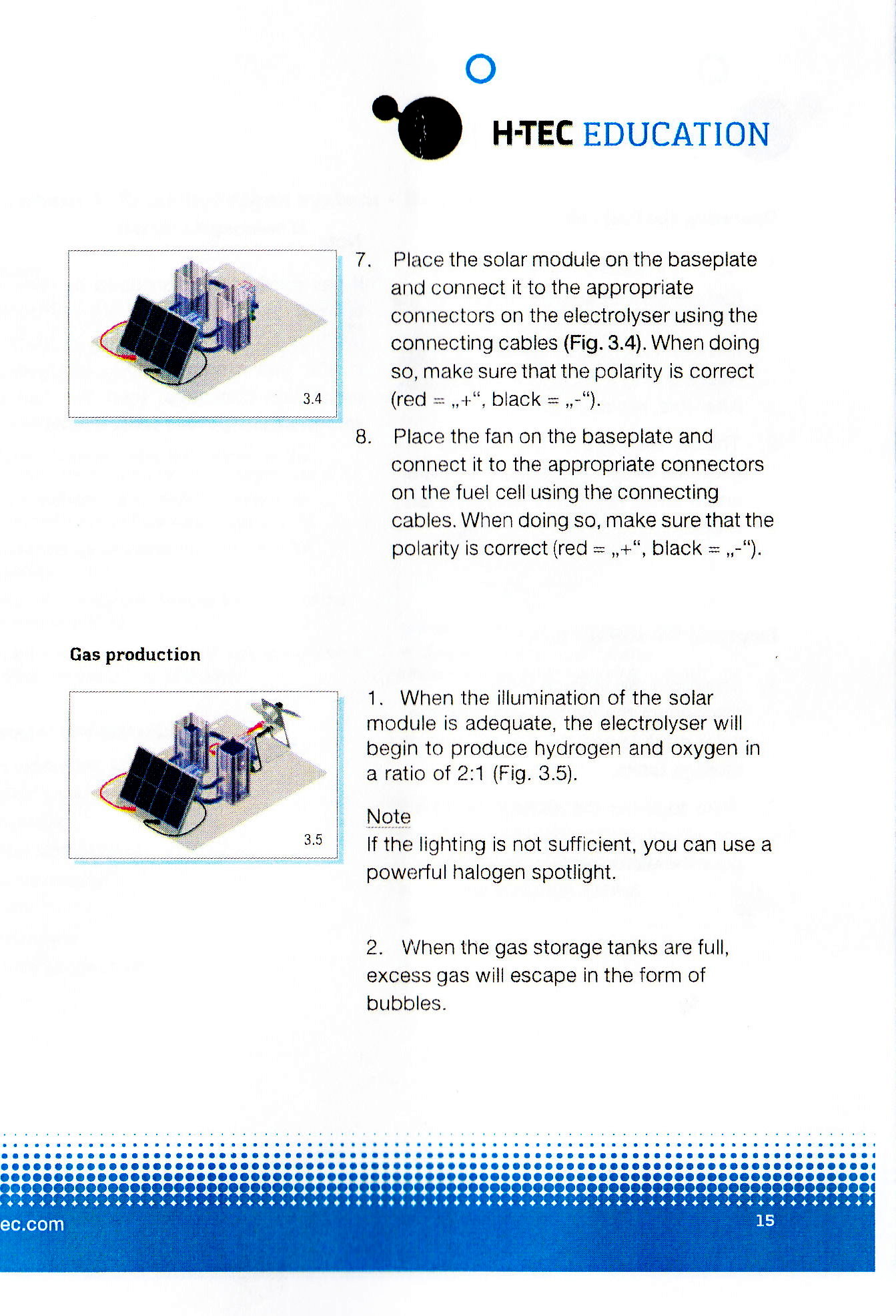
b. Describe how a Fuel Cell works.

**APPENDIX – Setup and Operation of Fuel Cell Apparatus**

**NOTE: you probably don’t need to do any setup**







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