Experiment 07

Hydrogen

Objective

Students observe that solar energy can be used to generate hydrogen. Hydrogen that is generated from solar energy can be later used as a fuel and as such, it can be regarded as "stored" solar energy.

Bubbles of Hydrogen (left) and Oxygen (right).

Value

Hydrogen may well be the fuel of the future. It is estimated that the world's oil reserves will be exhausted in under 50 years; natural gas reserves in under 70 years; and coal reserves in 200 years.[1] Additionally, global warming and climate change are linked to humanity's use of fossil fuels.

Hydrogen has been conceived of as the replacement for fossil fuels and its use is the technological driving force behind a potential "hydrogen economy".

Presently, the majority of the world's hydrogen originates from natural gas or other hydrocarbon fuels. If renewable energy sources like sunshine, wind, biomass or hydroelectricity were used as the starting point in hydrogen production, hydrogen would be a renewable and clean energy source.

Commercially, new cars are being designed to use hydrogen and fuel cells. A hydrogen fuel cell converts hydrogen and atmospheric oxygen directly into electricity with the only by-products of the process being heat and water vapour. Currently, hydrogen fuel cells are about 50% efficient (the theoretical efficiency is 83%) and internal combustion engines are about 25% efficient. A fuel cell and electric motor combined are much lighter in weight than an equivalent internal combustion engine. This allows for lighter, more efficient vehicles.

Equipment

A Hoffman's Voltameter; 10-watt, 12-volt solar module; multimeter (in current mode); multimeter (in voltage mode); alligator leads; retort stand and clamps; and electrolyte solution.

1 United Nations Environmental Programme

Method

Using standard laboratory techniques, a weakly acidic electrolyte solution is prepared by slowly mixing 25 mL of concentrated sulphuric acid into 800 mL water.

The Hoffman's Voltameter is filled with the electrolyte solution and the solar module and multimeter (in current mode) are connected in series to the voltameter. A multimeter (in voltage mode) is placed across the voltameter.

Solar generation of Hydrogen.

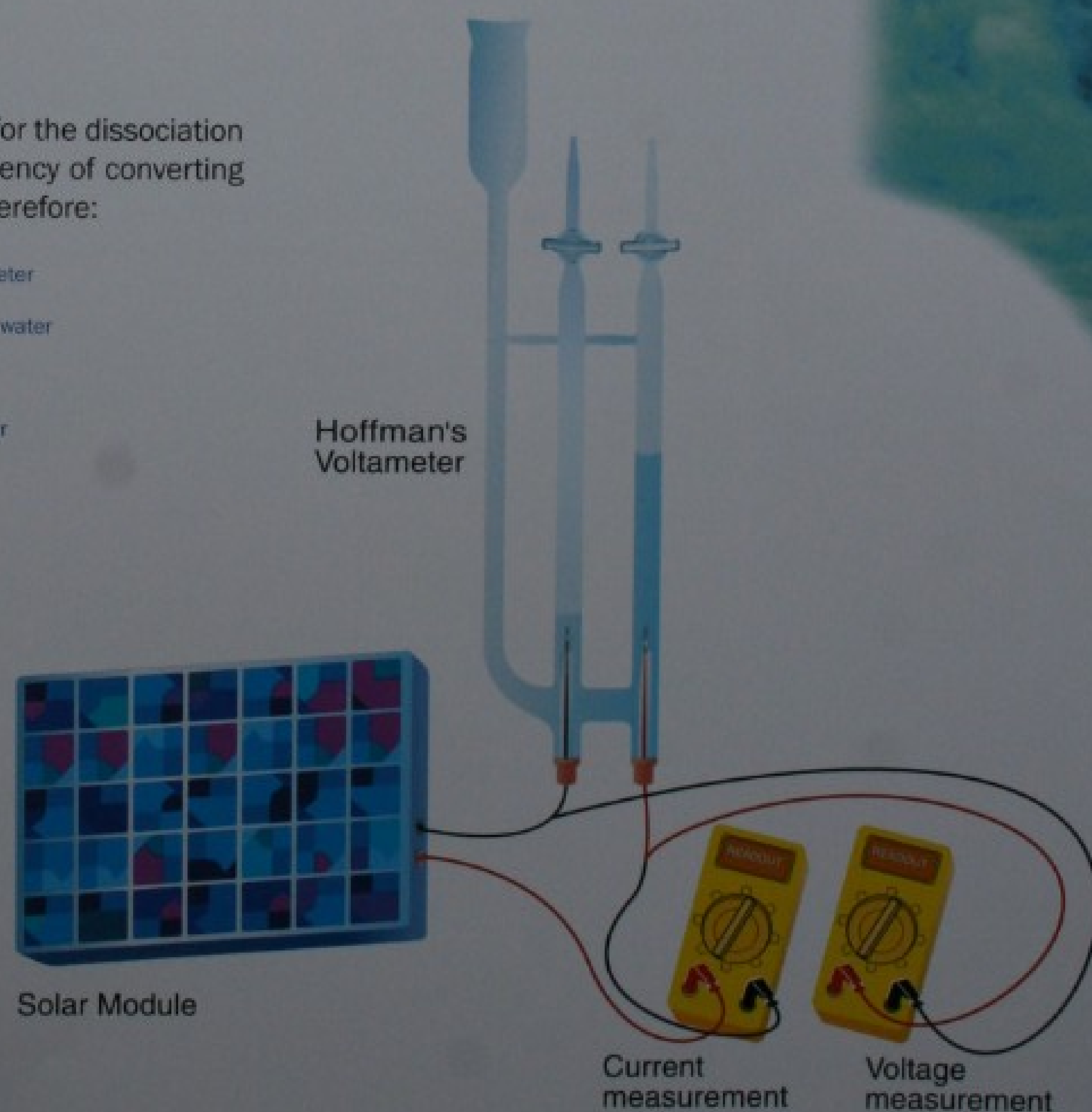
Position the solar module so that its surface is normal to the sunrays. Students should multiply the voltage and the current to yield power while observing the rate of hydrogen generation. The solar module is then moved so that it is at 45 degree to the sunrays. Students should again multiply the voltage and the current together to yield power and observe that the rate of hydrogen generation is reduced.

Notes

The theoretical voltage required for the dissociation of water is 1.23 volts. The efficiency of converting the electricity into hydrogen is therefore:

V = applied voltage across voltameter
I = current through voltameter
V_1 = voltage required to dissociate water = 1.23V
P = power produced by panel = $V \times I$
P_d = power used to dissociate water = $V_1 \times I$

$$\% \text{ Efficiency} = \frac{P_d}{P} \times 100 = \frac{V_1 \times I}{V \times I} \times 100 = \frac{V_1}{V} \times 100$$



The Hoffman's Voltameter will be approximately 10% efficient. If the solar module is also 10% efficient then the conversion efficiency of turning sunlight into hydrogen in this experiment is approximately 1%. Worldwide, considerable research is going into improving these efficiencies.