Name ____________________ Date __________ Class __________

Electrolysis of Water

Small Scale Lab 61

Introduction

Most people studying science know that the chemical formula of water is H_2O, and that the letters *H* and *O* represent hydrogen and oxygen, the elements that comprise water. People know this because they were taught it, not because it is obvious from looking at water. For most of history, philosophers considered this clear liquid, which is an essential part of life, to be an element. In the mid-1780s, Antoine Lavoisier realized that water did not fit his new definition of elements, since it could be produced from burning hydrogen and oxygen, and it could be decomposed over high heat. In 1800, water was split into hydrogen gas and oxygen gas using electricity.

In this investigation you will use electrolysis to investigate the chemical makeup of water and the nature of the electrochemical half reactions that occur at each electrode, resulting in the decomposition of water. An electrolyte, sodium sulfate (Na_2SO_4), is used in solution to facilitate electrical conductivity because it does not itself undergo electrolysis under the given conditions.

Pre-Lab Discussion

Read the entire laboratory investigation and the relevant pages of your textbook. Then answer the questions that follow.

1. Which electrode supplies electrons to positively charged ions?

2. At which electrode does oxidation (loss of electrons) occur? Is this electrode positively or negatively charged?

3. Why does the electrolysis process stop if the electrodes come in contact with each other, or short circuit?

4. Why should you avoid touching the metal electrodes to each other or to your fingers while they are connected to the power source?

5. When should you terminate the electrolysis reaction?

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Problem

What are the electrolysis products and half reactions for the decomposition of water?

Materials

chemical splash goggles
laboratory apron
petri dish bottom or cover
distilled water
sodium sulfate (Na_2SO_4)
2 platinum or stainless-steel insulated electrodes
pH indicator solution
micropipet
2 small test tubes
microscope-slide coverslip
2 notched sponge blocks
metric ruler
9V battery with snap-on leads, or DC power supply with leads

Safety

Wear your goggles and lab apron at all times during the investigation. To avoid possible shock or burns, do not touch bare wires from the power source or short the wire leads by touching them together. If you spill sodium sulfate or pH indicator on your skin or clothing, wash it off immediately with plenty of water and tell your teacher.

Note the caution alert symbols here and with certain steps of the Procedure. Refer to page *xi* for the specific precautions associated with each symbol.

Procedure

1. Put on your goggles and lab apron. Fill a petri dish or other shallow container nearly full of distilled water. Sprinkle the water with several grains of sodium sulfate (Na_2SO_4) and stir with one of the electrode tips to dissolve. Add a few drops of pH indicator.
2. Use a micropipet to fill two small test tubes with the solution from the dish. Overfill them slightly.
3. Place a microscope-slide cover slip over the mouth of one of the test tubes to trap the solution. Invert the test tube in the dish of electrolyte solution. Incline the filled test tube with its mouth still submerged in the dish of electrolyte solution. Rest the test tube on a notch in a block of moistened sponge placed outside the dish, as shown in Figure 61–1. Repeat the process for the second test tube.
4. Slide an electrode tip into the submerged mouth of each test tube. Rest the tops of the electrodes on notches in a second sponge block. Be careful as you move each electrode into position that you do not accidentally lift the test tube mouth above the surface. If you do, you will have to refill the test tube.

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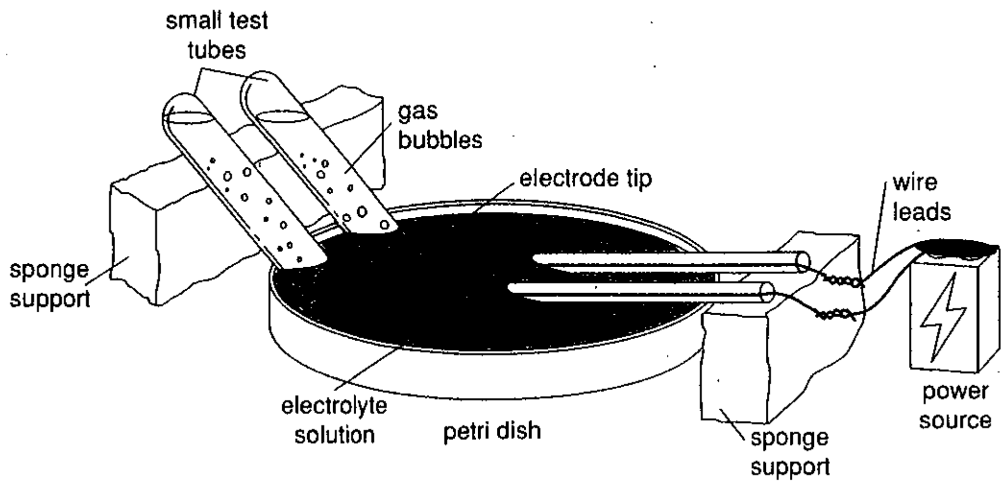

Figure 61–1

5. Connect a 9-volt battery lead, or DC power supply lead, to each electrode. Note which electrode is negative and which is positive. **CAUTION:** *Be careful not to touch the power source leads together, as this may cause the leads to become hot and may damage the battery or power supply.*

6. Soon after connection, you should see gas bubbles rising into the test tubes from each electrode. A little later, look for color changes, indicating a change in pH. Record in the Data Table the color changes at the anode and cathode, and the pH range as indicated in the following table.

TABLE 61–1 pH Ranges of Indicators

	pH < 7	pH = 7	pH > 7
phenol red	yellow	orange	red
bromthymol blue	yellow	green	blue

7. When one test tube is at least half full of gas, disconnect the electrodes, being careful not to short the leads by touching them. Remove the electrodes carefully, keeping the test-tube mouths below the surface of the solution. Holding each tube vertically in the dish, and, being careful not to lift the test-tube mouth above the surface, measure the height of gas in each tube in millimeters. Record in the Data Table the height of gas in each tube relative to the electrode at which it was produced.

8. Discard the electrolyte solution down the drain. Rinse the outside of the electrode casings and tips, the test tubes, and the dish with plenty of water. Clean up your work area and wash your hands before leaving the laboratory.

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Observations (sample data)

DATA TABLE

	Anode	Cathode
pH indicator color		
indicated pH range		
height of gas generated (mm)		

Critical Thinking: Analysis and Conclusions

1. From the information in your text, write the half reactions that occur in this investigation. *(Interpreting data)*

2. Based on pH-indicator observations, at which electrode are there excess H^+ ions? Which electrode is H^+-deficient (OH^- in excess)? *(Interpreting data)*

3. Based on your answers to Questions 1 and 2, identify the electrode at which each reaction is occurring. *(Making inferences)*

4. Add together the two equations for the half reactions from your answer to Question 1 to obtain the overall reaction. Then write the net equation for the reaction. Explain how you reduced the terms in the net equation. *(Making inferences)*
   overall reaction:

5. Calculate the ratio of hydrogen gas to oxygen gas produced in the reaction. *(Interpreting data)*

6. What evidence do you have from the data that supports the accepted formula of water? *(Interpreting data)*

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Critical Thinking: Applications

1. If sodium chloride (NaCl) is used as an electrolyte instead of Na_2SO_4, hydrogen is produced, but at the other electrode little gas is collected. Instead, the electrolyte smells pungent like bleach. What ion from the electrolyte could account for this, and what is the half reaction that is occurring? *(Making predictions)*

2. How could you prove that the sodium sulfate (Na_2SO_4) electrolyte did not react in your electrolysis cell? *(Designing experiments)*

3. If you used concentrated hydrochloric acid as the electrolyte solution, what products would you be likely to get? In what ratio?