**Electrolysis of Water**

Electrochemistry is the study of the relationship between electrical forces and chemical reactions. There are two basic types of electrochemical processes. In a voltaic cell, commonly known as a battery, the chemical energy from a spontaneous oxidation– reduction reaction is converted into electrical energy. In an electrolytic cell, electricity from an external source is used to “force” a nonspontaneous chemical reaction to occur. What chemical reaction will take place when an electric current flows through water?

The first electrochemical process to produce electricity was described in 1800 by the Italian scientist Alessandro Volta, a former high school teacher. Acting on the hypothesis that two dissimilar metals could serve as a source of electricity, Volta constructed a stacked pile of alternating silver and zinc plates separated by pads of absorbent material soaked in saltwater. When Volta moistened his fingers and repeatedly touched the top and bottom metal plates, he experienced a series of small electric shocks. The “voltaic pile,” as it came to be called, was the first battery—a chemical method of generating an electric current. Within months, William Nicholson and Anthony Carlisle in England attempted to confirm the production of electric charges on the upper and lower plates in a voltaic pile using an electroscope. In order to connect the plates to the electroscope, Nicholson and Carlisle added some water to the uppermost metal plate and inserted a wire to the electroscope. To their surprise, Nicholson and Carlisle observed the formation of a gas, which they identified as hydrogen. Nicholson and Carlisle then filled a small tube with river water and inserted wires from the voltaic pile into each end of the tube. Two different gases were generated, one at each wire— Nicholson and Carlisle had discovered electrolysis.

Pencil lead

9

V

Clip

(+)

(

–

)

Battery

Alligator

+

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**Procedure**

1) Place the bottom half of a Petri dish on a white sheet of paper. Pour enough sodium sulfate solution into the

dish to just cover the bottom. Universal indicator has

Na2SO4

(solution)

been added to the solution – it should be green color

indicating a neutral pH.

2) Attach small pieces of pencil lead to opposite sides of the Petri dish bottom with the alligator clips. Make sure the tip of each lead is submerged in the green solution and the alligator clips remain out of the solution.

3) Clip the 9-volt battery into the snaps on the battery cap.

4) Let the current run for about 1 minute and note the changing colors. Disconnect the battery and stir the solution with a stirring rod and note the resulting color. Reconnect the battery and note the change in colors again and the production of gases (bubbling) at each electrode over 5-10 minutes. Record observations (and take photos) of the changes that occur. Disconnect the battery. Remove the graphite electrodes and rinse them with distilled water and dry them with a paper towel.

6) Use colored pencils to make a sketch of the Petri Dish. (take a photo and print in color?)

7) Stir the solution with a stirring rod and make note of the result. Is it the same as before?

Universal indicator is an acid–base indicator that is different colors at different pH values.

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **pH** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **Color** | Red | Orange | Yellow | Green | Blue/green | Dark blue | Purple |

**Electrolysis of KI and NaCl Solutions**

1) Pour enough 0.5M KI solution into a clear petri dish to cover the bottom and add 3 drops of phenolphthalein

solution. Stir with a stirring rod to mix. (Rinse and clean the stirring rod!)

2) Connect the battery to the snaps. Use the alligator clips to attach the graphite pencil electrodes to opposite sides of

the petri dish.

3) Let the current run for 1-2 minutes while observing changes at each electrode. Record your observations.

(Take photos.)

4) Remove the graphite electrodes from the solution. Carefully rinse the electrodes with distilled water and dry them

with a paper towel.

5) Add 2 drops of starch solution to the dish near the ANODE (+) and record your observations.

***(Formation of black color indicates the presence of iodine.)***

6) Dispose of the solution in the sink. Rinse the petri dish clean and dry with a paper towel.

7) Add enough 0.5M NaCl solution to cover the bottom and add 3 drops of phenolphthalein solution.

Stir with a stirring rod to mix. (Rinse and clean the stirring rod!)

8) Repeat steps 3 and 4 for this solution. Record your observations. (Take photos.) *(Note any odor of the gas.)*

9) Add 3 drops of KI solution near the ANODE (+) followed by one drop of starch and observe – record your observations.

***(This test indicates the presence of chlorine which oxidizes the added iodide ions to produce iodide – a dark blue color should form in the solution.)***

10) Dispose of the solution in the sink. Rinse the petri dish clean and dry with a paper towel.

Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date \_\_\_\_\_\_\_\_\_ Period \_\_\_\_

9

V

(+)

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+

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**Electrolysis of Water**

**Observations**

**Analysis**

1) Explain the difference between a voltaic cell and an electrolytic cell.

2) Use the table of Standard Reduction Potentials to determine the 2 possible half-reactions that can occur at each

electrode and write them below with the correct potential value. *(Hint: what species are present in the solution?)*

CATHODE ANODE

3) Use your observations and the potential voltages to determine which reaction is occurring at each electrode.

Explain your choices.

4) Show how the reactions at each electrode can be added to produce the overall reaction for the electrolysis of water.

(Include the Eo for each reaction.) Calculate the minimum voltage needed for the electrolysis of water.

5) Explain why sodium sulfate was added to the water.

6) Explain the 2 functions of the pencil lead (graphite) electrodes.

7) Compare the rates gas evolution at the anode and cathode. Identify the gas produced at each.

8) Explain what happened when the solution was stirred after the first minute. What caused this color?

9) Think about the flow of electrons and current in this experiment. What do the + and – signs on a battery signify? Explain how the current flows in this experiment. How were the names anode and cathode determined for the electrolytic cell?

**Electrolysis of KI and NaCl Solutions**

|  |  |  |  |
| --- | --- | --- | --- |
| **Electrolyte**  **(Salt Solution)** | **Observations** | | |
| **Anode** |  | **Cathode** |
| **Potassium Iodide** |  |  |  |
| **Sodium Chloride** |  |  |  |

1) What product was formed at the anode during the electrolysis of the KI solution? Explain citing specific evidence.

Write the half-reaction for this process. *(Include the voltage.)*

2) What products formed at the cathode during the electrolysis of the KI solution? Explain citing specific evidence.

Write the half-reaction for this process. (*Include the voltage.)*

3) Show how the reactions at each electrode can be added to produce the overall reaction for the electrolysis of the KI solution. (Include Eo for each). Calculate the minimum voltage necessary for the electrolysis of the KI solution.

4) What product was formed at the anode during the electrolysis of the NaCl solution? Explain citing specific

evidence. Write the half-reaction for this process. *(Include the voltage.)*

5) What products were formed at the cathode during the electrolysis of the NaCl solution?

Explain citing specific evidence. Write the half-reaction for this process. *(Include the voltage.)*

6) Show how the reactions at each electrode can be added to produce the overall reaction for the electrolysis of the NaCl solution. (Include the Eo for each.) Calculate the minimum voltage needed for the electrolysis.

7) Look up the voltage needed for the *oxidation* of chloride ions to chlorine gas. *(Remember this is oxidation.)* \_\_\_\_\_\_V

Is this voltage more or less favorable that the oxidation of water to oxygen observed in the first part of the lab?

Explain.

8) Research the reason for why oxidation of the chlorine occurs over the oxidation of the water. *(hint: kinetics)*