Experiment # ٣

Title of experiment: Difference between a galvanic cell and an electrolytic cell

Aim:

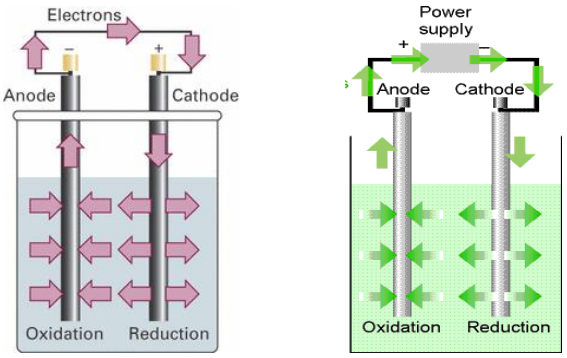
There are two types of electrochemical cells; galvanic and electrolytic cells. The former one is known to have a spontaneous cell reaction with a **negative** value for $\Delta_r G$ whereas the latter is distinguished by a non-spontaneous reaction with a **positive** value of $\Delta_r G$.
In this experiment, you will learn how to setup the two types of electrochemical cell and measure their potential.

Introduction:

A galvanic cell (left photo) is a system in which an oxidation-reduction reaction occurs spontaneously. The oxidation and reduction half-reactions are separated so that the current moves through an external wire. This spontaneous reaction produces an electrical potential. The potential for any galvanic cell can be calculated using the standard reduction potentials using the equation

$$E°_{cell} = E°_{reduction} - E°_{oxidation} \qquad (1)$$

In an electrolytic cell (right photo), electricity is supplied externally to drive a nonspontaneous redox chemical reaction. This process is known as ***electrolysis***.



Source: Physical chemistry, Atkins & Paula

As in galvanic cells, the number of electrons required to drive electrolysis is directly related to the number of electrons needed in the reduction half reaction. One of the famous electrolysis reaction is the evolution of hydrogen gas from an acid solution where the hydrogen ions are reduced at the cathode, usually a metal, to give hydrogen gas as:

$$2H^+ (aq) + 2\ e^- \longrightarrow H_2 (g) \qquad (2)$$

Reduction of H^+ ions to form hydrogen gas can be a spontaneous reaction if the metal has a standard reduction potential lower that of H^+/H_2 whereas it can be non-spontaneous if the metal has a higher standard reduction potential lower that of H^+/H_2.
The objective of this experiment is:

1. To setup a galvanic cell
2. To setup an electrolytic cell

3. To distinguish between galvanic and electrolytic cells.
4. To measure the relative reduction potentials for a number of redox couples in a galvanic cell.
5. To identify the reactions occurring at the anode and cathode during the electrolysis of various aqueous salt solutions.
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Materials:

100 ml beaker (3); Sandpaper. Battery 9 V, digital multimeter with alligator clip leads, tib.
Ag, Cu and Zn wires or rectangular sheets and Two sharp pencil (as graphite electrode),
0.50 M $AgNO_3$; 0.25 M $Cu(NO_3)_2$; 0.25 M $Zn(NO_3)_2$;; 200 ml of H_2SO_4 1M.
2 salt bridge (h- type), and 1 salt bridge (u-type) filled with saturated KNO_3 solution.

Procedure:

1) Prepare a salt bridge using saturated KNO_3 solution.
2) For **the galvanic cell** polish Ag and Zn electrodes with sand paper until shiny. Then rinse them by distilled water and dry it in air. For Cu rinse it in distilled water and dry.
3) Take a rubber band and hold three small test tubes together, Label one with A , C and Z for $AgNO_3$, $Cu(NO_3)2$, M $Zn(NO_3)_2$ solutions respectively.
٤) Place a salt bridge in two test tubes with Ag and Zn solutions.
٥) Insert the Ag and Zn electrodes in the corresponding solutions and attach the positive wire of the volt meter to the Ag metal and the negative wire to Zn metal and record the potential and your visual observation.
٦) Repeat step #٥ using Ag and Cu electrodes and record the potential of the cell and your visual observation.
٧) Repeat step #٥ using Cu and Zn electrode and record the potential of the cell and your visual observation.
٨) For **electrolytic cell**, use a Zn anode and graphite cathode. The solution is 1M H_2SO_4 .
٩) Connect the two electrodes to the volt meter and measure the potential. In the same time, observe if any reactions are undergoing at the electrodes or any gases are evolved.
١٠) Repeat step 9 using a graphite anode and measure the potential. In the same time, observe if any reactions are undergoing at the electrodes or any gases are evolved. Now connect the graphite electrode to the negative pole of the power supply and the Zn electrode to the positive pole. Observe any activity at the electrode surface. Observe the volume of the gas evolved as a function of time. Record your observation in table 2.

Results:

Using the given galvanic cells and recording the measured potentials at a known temperature in table 1 given below and determine the polarity of each cell and the reactions of its electrodes.

Table 1 Experimental data-

Redox couples	Potential, V	Cathode reaction	Anode reaction
Ag-Zn			
Ag-Cu			
Cu-Zn			

Table 2 Experimental data of an electrolytic cell

Redox couples	Potential,V	Cathode reaction	Anode reaction
Zn-graphite			
Graphite-graphite			