Coulometric Titration of HCl

This experiment is described in Section 17-3. Before Lab please complete questions 17-13 and 17-14 in your text.

Coulometry is an electrochemical procedure in which a redox reaction produces the titrant in a titration instead of delivering the titrant with a pump or other volumetric device. Because we can measure current very accurately, it is possible to obtain excellent precision and accuracy with coulometric titration.

A coulometric cell is an electric circuit in which a battery or power supply drives a nonspontaneous redox reaction. In our cell the cathode reaction produces base and the anode produces silver chloride:

\[
\begin{align*}
2H_2O + 2e^- & \rightarrow H_2 + 2 OH^- & \text{cathode} \\
Ag(s) + Cl^- & \rightarrow AgCl(s) + e^- & \text{anode}
\end{align*}
\]

These two cells are separated in space with a glass frit or membrane. Since the cathode reaction produces base we can perform an acid titration in the cathode cell. We will follow the progress of the titration using a pH indicator and a colorimeter based on a red LED.

![Coulometric Cell Diagram](image)

Figure 1. Coulometric Cell.
The moles of base produced at the cathode may be computed from the integrated current that flows through the electrochemical cell and the Faraday constant.

\[
\text{Moles e}^- = \frac{\left( \int_{0}^{t} idt \right)}{F}
\]

Notice that one mole of hydroxide is produced per mole of electrons.

We do not have enough ampmeters for the entire class. Instead we will measure the voltage drop across a 10 \( \Omega \) resistor and compute the current. The endpoint of the titration will be detected by the change in solution color produced when the added pH indicator becomes deprotonated.

Procedure:

1. Prepare 500 ml of 0.1 M HCl
2. Assemble the coulometer shown in Figure 1.
3. Fill the sample cell with water and add 3 drops of indicator. Add a few drops of acid and observe the color of the solution and notice the signal produced on the colorimeter. Next add a few drops of base and notice the color of the solution and the signal on the colorimeter. This simple exercise illustrates the endpoint determination of the system
4. Fill the sample cell 3/4 full with saturated KCl. Add enough acid to require a 3 to 6 minute coulometer run assuming a coulometer current of 0.2 amps.
5. Run the coulometer three times and compute the mean and standard deviation of your HCl solution. Use the integration tools in Logger Pro to compute the total charge passed through the coulometer.