Determination of the Electron Charge[1]

Equipment Needed:

1 Plating Apparatus/2 copper plates	Demo cart
1 Power Supply	Demo cart
1 Digital Multimeter	Demo cart
1 Rehostat	Demo cart

Purpose

This experiment is to determine the charge on the electron by the electrolysis of copper sulfate.

Apparatus

Before beginning the lab, assemble the two copper electrodes, support for electrodes, switch, rheostat (about 22Ω), ammeter, set of weights, sandpaper, centimeter scale, bundle of connecting wires, and watch (furnished by the student).

You will also need a power supply as the source of dc current and copper sulfate solution as the electrolyte.

Introduction

The smallest quantity of eletric charge in existence is believed to be the amount of charge on a single electron. The charge on the electron is considered as a negative charge and its magnitude is represented by the symbol e. Consequently, the smallest quantity of positive charge obtainable would be that found on an atom which has lost one electron to become a positive ion. The magnitude of this charge is also e. Chemist have proven that copper atoms in copper sulfate are bivalent or that in a solution of this salt, the sulfate ion $(S0_4^{--})$ takes two electrons from the copper atom forming a copper ion (Cu^{++}) with a charge of $2e$. In this experiment we hope to measure the charge on a large number of copper ions and then be able to compute the value of e, the charge on one electron. Chemists have found the atomic weight (M) of copper to be 63.54. The number of molecules in a gm-mole of any substance has been found to be 6.02×10^{23}, and this number, called Avogadro's

[1]Adapted from PASCO Photogate Timers ©1994, PASCO Scientific Roseville, CA

number, is usually designated by the symbol N_A. In a monoatomic such as copper. N_A is also the number of atoms in a gm-mole. Hence, in any known mass of copper it is possible to determine the number of atoms present. The only other information needed, for determining the electrical charge is the value of the total charge associated with this known mass of atoms when ionized.

If an electric current is passed through an electrolyte such as a copper sulfate solution with the arrangement shown in Figure 1. Positive copper ions are attracted to the negative electrode (or cathode). These copper ions take their needed two electrons from the cathode, and at the same time, change to uncharged electrons and deposit on the electrode. Hence, by weighing the electrode before the current is turned on and then again after some particular mass of copper has been deposited, the number of atoms deposited can be determined from the difference in the two weights. **NOTE: Be sure to clean contacts on the cover for 2nd trial.** If a current I is allowed to flow through the copper solution for a time **t**, the quantity of positive charge q transferred to the cathode by the copper ions is given by $Q = It$, where Q is in coulombs (C), I in amperes (A), and t in seconds (s). With the number of atoms known from the gain in weight of the cathode, and the total charge carried by this number of atoms. It is a simple computation to determine the charge that each copper atom carried as a positive ion. Then since each ion has a charge of $2e$, the charge on the electron is easily found.

Procedure

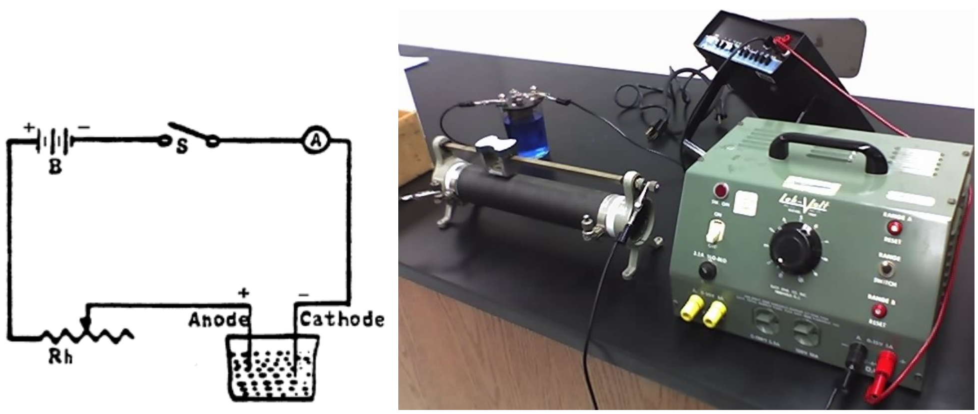

Figure 1: Equipment Layout

1. Select one of the copper plates to be your cathode and, unless it has a fresh deposit of copper on it, clean it with sandpaper or emery cloth. When cleaned, rinse it in

a stream of running water being careful not to touch the cleaned surface with your hands and dry the copper plates.

2. Rinse the $200ml$ jar thoroughly with water and fill it with copper sulfate solution until the liquid level is a little below the points of suspension of the plates in the jar.

3. Weigh the dry copper plates on the electronic balance to the nearest milligram, and record the weights of both the anode and the cathode in the tables below. The electronic balance is a very delicate instrument, and if you are not familiar with it, ask a facilitator to explain how it operates.

4. Place the plates in the solution and do not mix up the cathode with the anode. At a time of 0 minutes turn the power supply on and note the current. Run this current for 20 minutes. During this time, the current may fluctuate slightly, if so, *adjust either the power supply or the rheostat to keep the current at* $1.0A$.

5. Now remove the cathode and anode, rinse carefully in clear water. Dry and weigh again.

6. Repeat the experiment but now with a current of $1.5A$.

7. Compute the gain in mass of the cathode (Δm_c) and by use of the atomic mass of copper ($M = 63.54g$) and Avogadro's number (N_A), determine the number of Copper atoms (N_{Cu}) and electrons (N_e) deposited on plate. Show this computation as a part of your report using:

$$\begin{aligned} N_{Cu} &= \frac{N_A \Delta m_c}{M} \quad \Rightarrow \quad N_e = 2N_{Cu} = \frac{2N_A \Delta m_c}{M} \\ Q &= It \\ \Rightarrow e &= \frac{Q}{N_e}. \end{aligned}$$

8. You can now compute the total charge carried by the copper ions. Next compute the charge an each ion and then the charge on a single electron. Record your computations and find the percent error of your measured value of e as compared to the accepted value of $1.6 \times 10^{-19}C$.

9. Pour the electrolyte back into the original container, thoroughly wash the battery jar and both copper plates, and set aside to drain while answering the questions about the lab.

Table 1: Electrolysis at $1.0A$ and $1.5A$

$I_{initial}$ (A)	1.0	1.5
Initial mass of cathode (g)		
Final mass of cathode (g)		
Change in mass of cathode Δm_c (g)		
Initial mass of anode (g)		
Final mass of anode (g)		
Change in mass of anode Δm_a (g)		
Total charge $Q = It$ (C)		
Electron charge e ($10^{-19}C$)		
Percentage difference		

Questions

1. What happens to the mass of the anode during the electroplating process? What happens to the atoms of the anode material?

2. What improvements would you suggest for this experiment?