Determination of the Charge on an Electron

Introduction

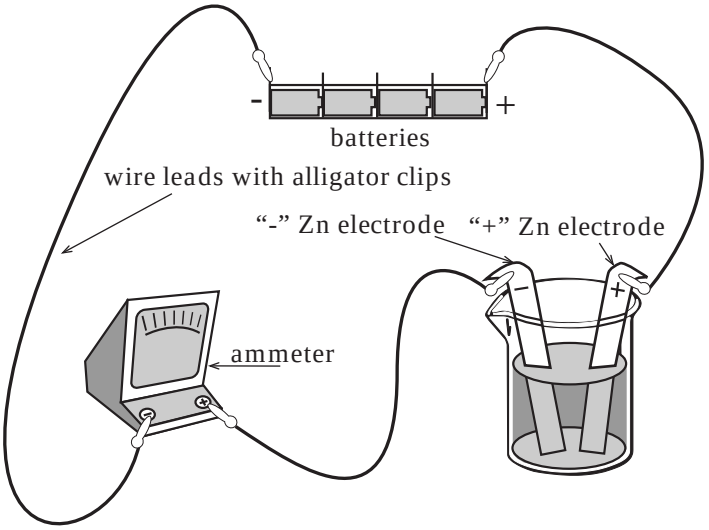
Robert Millikan, an American scientist, determined the charge on a single electron in 1909. You will be collecting data to make the same determination of the charge on an electron. Although your procedure will be different than Millikan's, your calculations should yield the same charge. You will be collecting zinc atoms on a zinc electrode to carry out this activity. Zinc ions, Zn^{2+}, will each gain 2 electrons to become neutral zinc atoms that "electroplate" on one of the zinc electrodes. The other zinc electrode will lose the same number of zinc atoms as they become zinc ions.

Materials

- 2 zinc electrodes (~3 X 10 cm)
- steel wool
- balance
- 250 mL beaker
- ~200 mL 1.0 M $ZnSO_4$ solution
- 3 wire leads with alligator clips
- battery holder
- 4 size "D" batteries
- ammeter
- distilled H_2O in squirt bottle
- goggles
- clock or watch with second hand

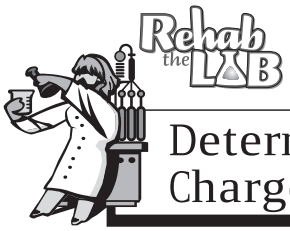
Procedure

1. Put on goggles. Lay the zinc electrodes on paper towels on your lab counter and polish both electrodes on both sides by rubbing with steel wool. Set electrodes on clean counter and carefully wad up paper towels with steel wool residue and throw away.
2. Using a pencil, label one electrode as "+" at the top of the metal zinc strip and the other as "–".
3. Find the mass of the "+" electrode and record. Repeat with the "–" electrode.
4. Place the electrodes in a 250 mL beaker so that the labeled ends are at the top of the beaker and the electrodes are on opposite sides of the beaker. Bend the tops over the rim of the beaker.
5. Place the 4 batteries all facing the same direction in the battery holder. Connect the "+" end of the batteries to the "+" electrode with the alligator clips of a wire lead. In similar fashion connect the "–" battery end to the "–" terminal on the ammeter with another wire lead. Finally, connect the "+" ammeter terminal lead to the "–" electrode. Have the set-up checked by your teacher before you continue. *(see illustration to the right)*



6. Remove the alligator clip from the "–" ammeter terminal. Pour $ZnSO_4$ solution into the 250 mL beaker containing the electrodes until it is about an inch or so from the rim.
7. Reconnect the ammeter and quickly adjust the current until the ammeter reads about 0.70 amperes. Record the amperage every minute for at least 20 minutes - 25 minutes is preferable!
8. Monitor the ammeter during data collection. If the reading changes 0.05 amps or more during a one-minute interval, wait until it is time to take the next reading and then readjust the current to about 0.70 amps.

(continued on back side)



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Data Table

Initial mass of "+" electrode _____g
Initial mass of "–" electrode _____g

Time (Minutes)	Current (Amperes)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
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25	

Final mass of "+" electrode _____g
Final mass of "–" electrode _____g

Procedure *(continued from front side)*

9. After your final timed ammeter reading, disconnect the wire leads. Carefully remove the electrodes and rinse with distilled H_2O from squirt bottle over sink. Place on clean paper towel that has been labeled with your names. Allow electrodes to dry over night in a clean safe place such as a drawer or cupboard.
10. Pour $ZnSO_4$ solution back into stock container so it can be reused. Clean up according to your teacher's directions and wash your hands.
11. After a drying period of at least 24 hours, find the mass of each electrode and record.

Analysis and Conclusions

1.a. Find the average of your ammeter readings.
b. Find the total time that you ran the experiment in seconds.
c. Multiply the average amperage by the total time in seconds to determine the total charge in ampere-seconds.

2. Calculate the change in the mass of each electrode.
"+" electrode: _____g
"–" electrode: _____g

3. Calculate the number of zinc atoms gained or lost at each electrode.
"+" electrode: _____Zn atoms
"–" electrode: _____Zn atoms

4. Divide the total charge (1. c above) by the number of atoms at each electrode (3 above) to calculate the charge per atom.
"+" electrode: _____[(ampere–seconds) / Zn atoms]
"–" electrode: _____[(ampere–seconds) / Zn atoms]

5. Calculate the charge per electron - remember that each Zn atom produces 2 electrons as it becomes a Zn^{2+} ion!
_____[(ampere–seconds) / electron]
_____[(ampere–seconds) / electron]

6. If one ampere-second equals one coulomb, how do your calculations compare to the accepted value as determined by Millikan of 1.60×10^{-19} coulombs? What is your % error for each electrode?
"+" electrode: _____% error
"–" electrode: _____% error