Sample lab report

The first page is the cover page for the report.

Title: Experiment #12 Determination of the Atomic Mass of Zinc (p 117, Hunt and Block)

YOUR NAME:________________________________________________

PARTNER(S) NAME:____________________________________________

DATE PERFORMED:_____________________________________________

DATE DUE:_____________________________________________________

DATE SUBMITTED:_____________________________________________
I. Introduction:

The purpose of this experiment was to determine the atomic mass of zinc. Zinc metal was oxidized to zinc ions with an electric current. See Figure 12.1 in Hunt and Block, second edition. When an electric potential is applied from the power supply through the electrochemical cell, zinc metal is oxidized at the anode forming Zn\(^{2+}\) ions. Simultaneously, hydrogen ions are reduced at the cathode to generate hydrogen gas. The overall reaction is:

\[
\text{Zn(s) + 2 HC}_2\text{H}_3\text{O}_2(\text{aq}) \rightarrow \text{H}_2(\text{g}) + \text{Zn}^{2+}(\text{aq}) + 2 \text{C}_2\text{H}_3\text{O}_2(\text{aq})\] (1)

The hydrogen gas was collected and measured in a eudiometer tube. The mass of zinc converted to Zn\(^{2+}\) ions was found by weighing a small piece of zinc before and after the electrolysis. From the balanced equation above, one can see that the number of moles of zinc oxidized is equal to the number of moles of hydrogen collected. From the volume of hydrogen gas one can find the moles of hydrogen gas collected. Dalton's Law of Partial Pressures, equation (2), and the Ideal Gas Law, equation (3) can be used to calculate the moles of gas:

\[
P_{\text{total}} = P_{\text{H}_2} + P_{\text{water}} + P_{\text{h}} = P_{\text{atm}}\] (2)

\[
PV = nRT\] (3)

where, \(P_{\text{H}_2}\) and \(P_{\text{water}}\) are vapor pressures of the hydrogen gas and water vapor inside the eudiometer tube, and \(P_{\text{h}}\) is the pressure due to the water column in the tube. A sum of the three pressures inside the tube, \(P_{\text{total}}\), must be equal to the atmospheric pressure. Then the moles of H2 collected is calculated using equation (4) below:

\[
n(\text{H}_2) = P_{\text{H}_2} V_{\text{H}_2}/(RT) = (P_{\text{atm}} - P_{\text{water}} - P_{\text{h}}) V/(RT)\] (4)

The mass of zinc metal oxidized divided by the number of moles of H\(_2\) at STP is equal to the atomic mass of zinc. Thus the atomic mass of zinc can be found using the following equations (5):

\[
\text{Atomic mass (Zn)} = \text{mass (Zn oxidized)/moles (Zn oxidized)}\] or,

\[
\text{Atomic mass (Zn)} = \text{mass (Zn oxidized)}/n(\text{H}_2).\] (5)

II. Procedure:

Directions given in the laboratory manual (p 118-119) were followed. The mass of zinc was recorded to four decimal places and the volume of H\(_2\) gas was measured to 2 decimal places (4 significant figures). This is done to maximize the number of significant figures in the data.
III. Tabulated Experimental Data:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of zinc at start</td>
<td>0.5175 g</td>
</tr>
<tr>
<td>Mass of zinc after reaction</td>
<td>0.4462 g</td>
</tr>
<tr>
<td>Mass of zinc reacted</td>
<td>0.0713 g</td>
</tr>
<tr>
<td>Volume of hydrogen collected</td>
<td>29.10 mL</td>
</tr>
<tr>
<td>$h$ 246 mm H$_2$O</td>
<td>(1.80 Torr)</td>
</tr>
<tr>
<td>Room temperature 22.0 ºC</td>
<td>(295.1 K)</td>
</tr>
<tr>
<td>Vapor pressure of water</td>
<td>19.8 Torr</td>
</tr>
<tr>
<td>Barometric pressure</td>
<td>740.0 Torr</td>
</tr>
<tr>
<td>Partial pressure of dry hydrogen</td>
<td>718.4 Torr</td>
</tr>
<tr>
<td>Moles of hydrogen collected</td>
<td>$1.136 \times 10^{-3}$</td>
</tr>
<tr>
<td>Moles of zinc reacted</td>
<td>$1.136 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

IV. Sample Calculations:

**YOU MUST SHOW ACTUAL DATA IN THE CALCULATIONS NOT JUST FORMULAS!**

**NOTE: YOU MAY HAND-WRITE ONLY THE EQUATIONS IN THIS SECTION**

The mass of zinc lost was 0.0713 g. The volume of hydrogen collected over water was 29.10 mL. The pressure of hydrogen in the eudiometer tube is found from Dalton's Law of Partial Pressure.

$$P_{\text{total}} = P_{H_2} + P_{\text{water}} + P_h = P_{\text{atm}}$$

Solve for the pressure of hydrogen gas:

$$P_{H_2} = P_{\text{atm}} - P_{\text{water}} - P_h$$

$$P_{\text{atm}} = 740.0 \text{ Torr (Barometric pressure)}$$

$$P_{\text{water}} = \text{the vapor pressure of water at 22.0C (19.8 Torr)}$$

$$h = 246 \text{ mm water, converting to cm of water 246mm x 1cm/10mm = 24.6 cm.}$$

To convert cm of water to cm of Hg or, Ph in Torr, 246 mm water x 1 cm Hg/13.6 mm water = 1.80 Torr.

$$P_{H_2} = P_{\text{atm}} - P_{\text{water}} - P_h$$

$$= 740.0 - 19.8 - 1.8 \text{ Torr} = 718.4 \text{ Torr}$$

The Ideal Gas Law was used to solve for the number of moles of hydrogen.

$$n = \frac{PV}{RT}$$
The units of the gas constant, R, and the experimental data must be consistent. If one uses
R=0.08206(L-atm)/(mol-K), then the pressure in Torr, (mm Hg), must be converted to atmospheres.

Thus, \( P = 718.4 \text{Torr}/(760\text{Torr}/atm) = 0.9452 \text{ atm} \).

Converting the mL of gas to liters we have, \((29.10 \text{ mL}) \times (1 \text{ L}/1000\text{mL}) = 0.02910 \text{ L} \).

The moles of \( \text{H}_2 \) can now be calculated from the Ideal Gas Law,

\[
\text{n(H}_2\text{) = \frac{(0.09452 \text{ atm}) (0.02910 \text{ L})}{(0.08206 \text{L-atm/mol-K})(295.13 \text{K})} = 1.136 \times 10^{-3} \text{ mol H}_2.\
\]

The atomic mass of zinc = mass (Zn oxidized)/n(H2).

Atomic mass (Zn) = 0.0713 g/1.136 x 10^{-3} mol = 62.8 g/mol.

**Calculation of Errors:**
The known value for the atomic mass of zinc is 65.37 g/mol. The experimental value was
62.8 g/mol. The absolute error is the difference between the known value and the measured value;

\[
(65.4 - 62.8)\text{g/mol} = 2.6\text{g/mol}.\
\]

The relative percent error is:

\[
\frac{(65.4 - 62.8)}{65.4}\times 100\% = 4.0\% \text{ error.}\
\]

**V. Tabulated Results of Calculations:**

<table>
<thead>
<tr>
<th>Partial pressure of H(_2)O</th>
<th>702.1 Torr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moles of H(_2) collected</td>
<td>1.136x 10^{-3} mol</td>
</tr>
<tr>
<td>Moles of zinc reduced.</td>
<td>1.136 x 10^{-3} mol</td>
</tr>
<tr>
<td>Atomic mass of zinc (from experimental data)</td>
<td>62.8 g/mol</td>
</tr>
<tr>
<td>Atomic mass of zinc (from periodic table)</td>
<td>65.4 g/mol (rounded from 65.37)</td>
</tr>
<tr>
<td>Absolute error</td>
<td>2.6 g/mol</td>
</tr>
<tr>
<td>Relative error</td>
<td>4.0%</td>
</tr>
</tbody>
</table>
VI. Discussion of Results and Conclusion:

During the experiment, the process of electrolysis generated hydrogen gas. By collecting the gas and applying the Ideal Gas Law, the number of moles of hydrogen for this sample was calculated to be $1.136 \times 10^{-3}$. The stoichiometry of the chemical equation indicates that this is same value for the number of moles of Zn reduced. The atomic mass of zinc was determined to be 62.8 g/mol. This experimental value can be compared to 65.4 g/mol, the value from the periodic table. There relative error in this experiment was 4.0%. The most significant source of error is in measuring the volume of hydrogen gas. If the accuracy of a eudiometer tube is ±0.2 mL, for this experiment the uncertainty is: $(0.2/29.10)*100\% = 0.67\%$

Other sources of error include the following:

The uncertainty in the mass of zinc, $(±0.0003/0.0713)*100\% = 0.42\%$.

The uncertainty in the temperature, $(±0.5K/303.2K)*100\% = 0.16\%$.

The uncertainty in the barometric pressure, $(±1Torr/740Torr)*100\% = 0.14\%$.

The uncertainty in h, $(±2mm water/(13.6*740mm)*100\% = 0.02\%$.

The approximate uncertainty in the water vapor pressure is, $±2/740*100\% = 0.27\%$.

The sum of the random errors is: $0.67\%+0.42\%+0.17\%+0.14\%+0.02\%+0.27\% = 1.68\%$.

A more rigorous estimation of the random experimental error is equal to the sum of the square root of the experimental errors squared. That is:

$$\sqrt{(0.67\%)^2+(0.42\%)^2+(0.17\%)^2+(0.14\%)^2+(0.02\%)^2+(0.27\%)^2} = 0.87\%$$

Seventy seven percent of the estimated experimental error, $(0.67/0.87/100\% =77\%)$, comes from the uncertainty in measuring the volume of hydrogen. This validates the statement that the major contributing factor to the experimental error is in the measurement of the volume of H$_2$ gas.

The actual relative error is $2.4 (4.0%/1.69\% = 2.4$) times greater than the estimated experimental error. It should be said that many of the experimental uncertainties used to calculate the overall experimental error actually are not known exactly. It is possible that the actual experimental errors are larger than those used in our estimated. If that is true, the value for the atomic mass of zinc could be within the range of experimental error for this experiment. It might be that the experimenter did not use the apparatus to the limits of accuracy.
VII. Conclusion
This experiment found the atomic mass of zinc to be 62.8g/mol. This is a 4.0% experimental error. This electrochemical method of determining atomic weight of a metallic element should be very reliable because the estimated error is only 0.87%. Refined technique and apparatus might result in a smaller experimental error.

Spelling, grammar, and writing style are important. Proof read the laboratory report and use the spelling checker in your word processor program!

PRE-LAB AND POST-LAB QUESTIONS ARE DUE WITH YOUR LAB REPORT

(Original by Dale Manos, 1995; Converted to an HTML file by M. H. Kim, 11/11/97)