Target Mole Lab

Mole Relationships and the Balanced Equation

Introduction

A common experiment in chemistry class is the reaction of zinc and hydrochloric acid. In this lab, students calculate how many zinc and chlorine atoms take part in the reaction, and then predict the mass of the solid product. The final grade will be determined by the electronic balance!

Concepts

- Average atomic mass
- Molar mass
- Mole concept
- Avogadro's number

Materials

For each student group

Hydrochloric acid solution, HCl, 3 M, 30 mL

Zinc metal sheet or strip, approximately 1-g piece (slightly different mass for each group)

Beaker, 250-mL

Beaker tongs

Graduated cylinder, 50-mL

Scissors

To be shared

Balances, electronic, 0.01-g precision, 3

Hot plates, 3

"HOT" signs, 3

Safety Precautions

Hydrochloric acid solution is toxic by ingestion or inhalation; severely corrosive to skin and eyes. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Label each 250-mL beaker with the respective student lab group number. Weigh and record the mass of each beaker.
2. Set out several labeled bottles or flasks of 3 M HCl solution for student access.
3. Set the hot plates in the fume hood. Turn on the hood and the hot plates at the beginning of the lab.
4. Place a "HOT" sign by each hot plate.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. After cooling, the beaker of waste zinc chloride may be rinsed and the solution disposed of down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b.

Tips

- Zinc chloride is deliquescent. Once the water and excess hydrochloric acid has boiled off, only let the beaker cool 2 minutes; otherwise, moisture from the air will be absorbed by the zinc chloride and affect the final mass.
- By weighing and recording the mass of each beaker in advance, the instructor may help students determine whether

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or not this was a possible source of error in measurement.

- More or fewer balances and hot plates may be used. Three is usually sufficient to prevent long wait times.
- The Commission on Isotopic Abundances and Atomic Weights recommended in August, 2007 that the atomic mass of zinc be changed from 65.409(4) to 65.38(2). The standard uncertainty is given in parentheses.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, chemical reactions

Sample Data and Answers to Worksheet Questions *(Student data and answers will vary.)*

Data Table

Beaker # _____

Mass of beaker (g)	*109.62*
Mass of beaker + zinc (g)	*110.62*
Mass of zinc (g)	*1.00*

Observations and Questions

1. What two observations indicate a chemical reaction is taking place (step 7)?

   Bubbles indicate a gas is being produced. The beaker is warm so heat is also produced.

2. What gas do you think is in those little bubbles? *Hint:* What is the only element left over?

   Hydrogen, H_2

3. What evidence indicates the reaction is finished (step 9)?

   No more bubbles are produced. All the zinc is gone.

4. Given the mass of the zinc that was calculated in the data table, how many atoms of zinc were placed in the beaker? Show your work in factor label form below. *Hint:* Your answer should be so large it will need to be in scientific notation!

$$1.00 \text{ g Zn} \times \frac{1 \text{ mole Zn}}{65.409 \text{ g Zn}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mole Zn}} = 9.20 \times 10^{21} \text{ atoms Zn}$$

5. How many chlorine atoms should have combined with that number of zinc atoms? *Hint:* This number should be even bigger than the answer above—remember the ratio in which the atoms combine.

   $ZnCl^2$ $\quad 9.20 \times 10^{21}\ atoms \times 2 = 1.84 \times 10^{22}\ atoms\ Cl$

6. How much will all these chlorine atoms weigh? Again show your work in factor label form.

$$1.84 \times 10^{22}\ atoms\ Cl \times \frac{1\ mole}{6.02 \times 10^{23}\ atoms} \times \frac{35.453\ g}{1\ mole\ Cl} = 1.08\ g\ Cl$$

7. Considering how much the beaker weighed with just the zinc atoms in it, how much will the beaker weigh now with the zinc and the chlorine atoms combined in it?

   $110.62\ g\ (beaker + zinc) + 1.08\ g\ Cl = 111.70\ g\ (beaker + ZnCl_2)$

8. Write a chemical equation using correct subscripts and (s), (g) and (aq) for the reaction between zinc and hydrochloric acid.

   $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(s) + H_2(g)$

9. Was the reaction above a chemical or physical one? How could you tell?

   The reaction was chemical. In addition to the observations listed in Question 1, the final product is different than the reactants.

10. After all the water had been boiled away, the viscous liquid left in the beaker was molten (liquid) zinc chloride. What happened to that molten zinc chloride as the beaker cooled? Was that a chemical or a physical change? How can you tell?

    The $ZnCl_2$ solidified. This is a physical change, involving only a phase change—no new products were formed.

11. What do you think would happen if you put the beaker back on the hot plate for a few minutes?

    The solid $ZnCl_2$ would melt.

12. How would the final results be affected if you hadn't heated the beaker long enough? Explain your answer.

    Water may have remained in the beaker, resulting in a total mass that would be greater than the predicted results.

13. DJ repeats the experiment except she uses aluminum instead of zinc.

    a. What is the correct (charge-balanced) formula for aluminum chloride?

    $AlCl_3$

    b. Write a chemical equation using correct subscripts and (s), (g) and (aq) for the reaction between aluminum and hydro chloric acid.

    $2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(s) + 3H_2(g)$

    c. Complete DJ's data table below.

Mass of beaker (g)	122.47
Mass of beaker + Al (g)	125.71
Mass of Al (g)	*3.24*

    d. Given this mass, how many atoms of aluminum were in the beaker? Show your calculations in factor label form.

$$3.24\ g\ Al \times \frac{1\ mole\ Al}{26.98\ g\ Al} \times \frac{6.02 \times 10^{23}\ atoms}{1\ mole\ Al} = 7.23 \times 10^{22}\ atoms\ Al$$

    e. Using the charge-balanced formula that tells you in what ratio the aluminum and chlorine combine, determine how many chlorine atoms should have combined with the number of aluminum atoms in the beaker.

    $AlCl_3$ $\quad 7.23 \times 10^{22}\ atoms \times 3 = 2.17 \times 10^{23}\ atoms\ Cl$

f. How much will all these chlorine atoms weigh? Show your work in factor label form.

$$2.17 \times 10^{23} \text{ atoms Cl} \times \frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ atoms}} \times \frac{35.453 \text{ g}}{1 \text{ mole Cl}} = 12.8 \text{ g Cl}$$

g. After she boils off all the water, how much should DJ's beaker weigh with the aluminum chloride in it?

125.71 g (beaker + Al) + 12.8 g Cl = 138.5 g (beaker + $AlCl_3$)

h. In fact, DJ's beaker with the aluminum chloride weighed 129.64 g. Based on the Scoring Table, what would her grade be?

The difference is within 10 g, but not within 5 g, so her grade would be 3.

14. Chemical reactions can be categorized as either exothermic (heat is given off by the reaction) or endothermic (heat is taken in by the reaction). What type of reaction is the one between Zn and HCl? How do you know this?

The reaction is exothermic. Since the beaker felt warm, heat was given off.

15. This lab is called a Target Mole Lab, and yet, moles are not mentioned anywhere in the *Procedure* or in the *Questions* (until now!). How did the mole concept play an important role in this lab?

The mole concept was used to calculate the number of atoms of Zn and Cl that took place in the reaction.

16. You want to build a deck off your kitchen and you estimate that you will need 3000 #8 nails all together. Rather than pay extra for them to be put in little boxes, you go to a hardware store where they sell nails in bulk. How does the sales clerk count out 3000 #8 nails for you?

The clerk would weigh the nails based on a standard weight given for a smaller amount of nails.

17. How is the above procedure comparable to what you did in the lab?

To determine the number of atoms involved in the reaction, the chemicals in this experiment were weighed.

18. The sales clerk was new and so she had to consult a chart to get the right amount of nails. What is this chart comparable to in the lab you did?

The periodic table was consulted to determine the molar mass of Zn and Cl.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Target Mole Lab* activity, presented by Bob Becker, is available in *Mole Relationships and the Balanced Equation* and in *Bob Becker Target Labs*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Target Mole Lab* are available from Flinn Scientific, Inc.

Catalog No.	Description
H0034	Hydrochloric Acid Solution, 3 M, 500 mL
Z0024	Zinc, Strips, Pkg/10
AP7234	Hot Plate, Flinn, 7″ × 7″

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Target Gas Law Lab Worksheet

In this lab you will count zinc atoms! In fact you will count out more zinc atoms than there are drops of water in Lake Michigan! And then you will take every zinc atom you've counted and carefully bond it with precisely two chlorine atoms! Be as precise as you can—your grade depends on it!

Safety Precautions

Hydrochloric acid solution is toxic by ingestion or inhalation; severely corrosive to skin and eyes. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines.

Procedure

1. Obtain a 250-mL beaker and write the beaker # above the Data Table.
2. Weigh the empty beaker on one of the balances. Record this mass in the Data Table.
3. Obtain a small sheet of zinc metal and holding the zinc over the beaker, use a pair of scissors to cut up the zinc into several long skinny strips (the skinnier the better). Allow these strips to drop into the beaker.
4. Weigh the beaker with the zinc pieces and record this mass.
5. Determine the mass of the zinc alone and record in the data table.
6. Use a graduated cylinder to measure out 25–30 mL of 3 *M* hydrochloric acid (HCl) solution, and then add the solution to the beaker. The Zn atoms will combine with the Cl atoms from the HCl in a 1:2 ratio to make the compound $ZnCl_2$.
7. Observe the reaction. The $ZnCl_2$ is soluble in the water so you won't see it. Also, feel the bottom of the beaker. Record your observations (Questions 1 and 2).
8. While you wait about five minutes for the reaction to finish, start answering Questions 4–7 below.
9. After 5–6 minutes, observe the beaker. Record your observations (Question 3).
10. Once the reaction is complete, place the beaker on one of the hot plates in the fume hood. It will take about five more minutes for all the water to be boiled off. While waiting, continue working on the questions below.
11. Once the rapid boiling stops, the water should all be gone. Use beaker tongs to remove the beaker from the hot plate. There should be a crusty white residue around the sides of the beaker (that's some of the $ZnCl_2$) and there may be a very viscous liquid on the bottom. *Note:* Zinc chloride has a relatively low melting point—only 275 °C!
12. Allow the beaker to cool for two minutes. When you are finished with Question 7 below, take this lab sheet and the beaker up to the instructor for the official weigh in! Your grade will be based on how close your prediction is to the actual mass according to the Scoring Table shown.
13. Rinse out your beaker into the sink and then dry it for the next class to use.

Data Table

Beaker # _____

Mass of beaker (g)	
Mass of beaker + zinc (g)	
Mass of zinc (g)	

Observations and Questions

1. What two observations indicate a chemical reaction is taking place (step 7)?

2. What gas do you think is in those little bubbles? *Hint:* What is the only element left over?

3. What evidence indicates the reaction is finished (step 9)?

4. Given the mass of the zinc that was calculated in the data table, how many atoms of zinc were placed in the beaker? Show your work in factor label form below. *Hint:* Your answer should be so large it will need to be in scientific notation!

5. How many chlorine atoms should have combined with that number of zinc atoms? *Hint:* This number should be even bigger than the answer above—remember the ratio in which the atoms combine.

6. How much will all these chlorine atoms weigh? Again show your work in factor label form.

7. Considering how much the beaker weighed with just the zinc atoms in it, how much will the beaker weigh now with the zinc and the chlorine atoms combined in it?

8. Write a chemical equation using correct subscripts and (s), (g) and (aq) for the reaction between zinc and hydrochloric acid.

9. Was the reaction above a chemical or physical one? How could you tell?

10. After all the water had been boiled away, the viscous liquid left in the beaker was molten (liquid) zinc chloride. What happened to that molten zinc chloride as the beaker cooled? Was that a chemical or a physical change? How can you tell?

11. What do you think would happen if you put the beaker back on the hot plate for a few minutes?

12. How would the final results be affected if you hadn't heated the beaker long enough? Explain your answer.

13. DJ repeats the experiment except she uses aluminum instead of zinc.

    a. What is the correct (charge-balanced) formula for aluminum chloride?

    b. Write a chemical equation using correct subscripts and (s), (g) and (aq) for the reaction between aluminum and hydro chloric acid.

    c. Complete DJ's data table below.

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Mass of Al (g)	

    d. Given this mass, how many atoms of aluminum were in the beaker? Show your calculations in factor label form.

    e. Using the charge-balanced formula that tells you in what ratio the aluminum and chlorine combine, determine how many chlorine atoms should have combined with the number of aluminum atoms in the beaker.

    f. How much will all these chlorine atoms weigh? Show your work in factor label form.

    g. After she boils off all the water, how much should DJ's beaker weigh with the aluminum chloride in it?

    h. In fact, DJ's beaker with the aluminum chloride weighed 129.64 g. Based on the Scoring Table, what would her grade be?

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