Predicting the Mass of a Chemical Product

PROBLEM

For a given amount of reactant, how can you tell how much product will be formed?

INTRODUCTION

Factories routinely purchase raw materials to make their products. The process is not haphazard. To run a business cost effectively, it is necessary to know how much raw material is needed to produce the product. The same is true in chemical plants. Fortunately, during a chemical reaction, mass is conserved. The balanced equation can predict how much product will form from a given amount of reactant. In this laboratory investigation, you will react a known amount of baking soda with an excess of acid. Then you will isolate one of the products and measure its mass in order to compare it to the mass predicted by the balanced equation.

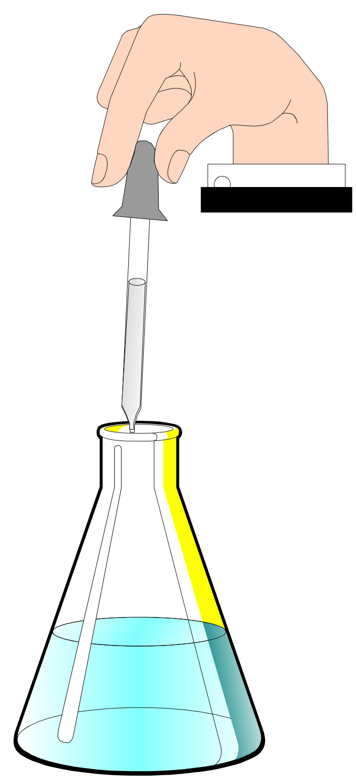
MATERIALS (*per group*)

Baking soda [$NaHCO_3$(s)]; balance; Bunsen burner; flask (250 mL); hydrochloric acid [HCl(aq)]; medicine dropper; ring stand and iron ring; safety goggles; scoop; tongs; wire gauze

PROCEDURE

1. Using a balance, measure the mass of an empty flask. Record the mass in the data table on the next page.

2. Using a scoop, add approximately 3 g of baking soda to the flask. Measure the mass of the flask and the baking soda. Record the mass in the data table on the next page. Calculate the exact mass of the baking soda in the flask. Record the result.



3. With a medicine dropper, add hydrochloric acid one drop at a time to the baking soda in the flask. Mix the contents of the flask by swirling it after addition of each drop of hydrochloric acid. Note what happens during the reaction with the addition of each drop of hydrochloric acid. Keep adding hydrochloric acid and mixing well until there is no more visible sign of a reaction.

4. Put on safety goggles. Set up a Bunsen burner, ring stand and iron ring, and wire gauze. Heat the flask containing the products of the chemical reaction to dryness (until there is no visible sign of moisture and no more steam). Then allow the flask to cool.

5. After the flask has cooled, measure the mass. Record the mass of the flask and the product on the data table (*First Heating*).

6. Reheat the flask for two minutes, cool again, and remeasure the mass. Record the mass in the data table on the next page. If the mass is the same as it was after the first heating, it is the final mass. If the mass is lower, heat the flask, cool, and remeasure the mass again. Repeat this step until the mass is constant. Then record the final mass.

7. Determine the mass of the product by subtracting the mass of the empty flask from the final mass of the flask plus the product.

8. Based on your observations, write a balanced equation for the reaction in the CONCLUSION section below. Then, using the exact amount of reactant from your data table below, fill in the mass-mass table below to determine the theoretical amount of product that should have formed.

9. Determine the absolute error by finding the absolute value of the difference between the theoretical and observed mass of the product. Calculate the percentage error by dividing the absolute error by the theoretical mass of the product and multiplying by 100%.

OBSERVATIONS

[a] Mass of the empty flask . . . . ___________

[b] Mass of the flask plus sodium bicarbonate . . . . ___________

[c] Mass of sodium bicarbonate (**b-a**) . . . . ___________

[d] Mass of flask and product after

- **[1]** *First heating* . . . . ___________
- **[2]** *Second heating* . . . . ___________
- **[3]** *Third heating* . . . . ___________
- **[4]** Final heating . . . . ___________

[e] Mass of product (**d4-a**) . . . . ___________

CONCLUSIONS

1. Balance the equation for the reaction: $\_\_NaHCO_3 + \_\_HCl \rightarrow \_\_NaCl + \_\_H_2O + \_\_CO_2$

2. Explain why NaCl will be the only product left in the flask after evaporation is complete. ____

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3. Complete the factor label problem below using the data you gathered to determine the theoretical mass of the product.

$$(1)\, g_{NaHCO_3} \times \frac{1 mol_{NaHCO_3}}{(2)\, g_{NaHCO_3}} \times \frac{(3)\, mol_{NaCl}}{(4)\, mol_{NaHCO_3}} \times \frac{(5)\, g_{NaCl}}{1 mol_{NaCl}}$$

(1) = observed mass of $NaHCO_3$ _________

(2) = GFM of $NaHCO_3$ . . . . . _________

(3) = Coefficient of NaCl . . _________

(4) = coefficient of $NaHCO_3$. _________

(5) = GFM of NaCl . . . . . . _________

[f] Theoretical mass of product . . . . ___________

4. Do an error analysis below:

[g] Absolute error (|**e-f**|) . . . . ___________

[h] Percentage error (**[g/f]×100**) . . . . ___________

5. Why doesn't it affect the results if you use a slight excess of acid in this reaction?

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