# Mole Ratio for a Chemical Reaction

#### **Performance Goals**

- 11–1 Carry out a reaction between a measured amount of sodium hydrogen carbonate, NaHCO<sub>3</sub>, and hydrochloric acid, HCl.
- **11–2** By weighing the solid product, derive the mole ratio in the reaction between the reactant and the product.

#### CHEMICAL OVERVIEW

In this experiment you will carry out a reaction where one of the products is a gas and the other is a solid.

$$NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O + CO_2(g)$$
 (11.1)

The above process will be carried out in a test tube. The "container" (see page 10) for this experiment, however, will be a beaker and the test tube. The beaker is necessary to hold the test tube on the balance in an upright position. Be sure to use the same beaker for each weighing.

To make sure that all the liquid has been evaporated, the solid residue should be "heated to constant mass." After the first heating, cooling, and weighing of the product, the test tube is heated, cooled, and weighed again. The two weighings should be within the plus-and-minus uncertainty of the balance used. If this is not the case, the heating procedure should be repeated again until the difference in mass is within the limits of the balance (about 0.005 for a milligram balance) between two consecutive weighings.

#### SAFETY PRECAUTIONS

Hydrochloric acid is corrosive. Avoid breathing the vapors and contact with skin. If acid should spill on you, *immediately* wash it off with *plenty* of water. *Extreme caution* should be exercised when heating the NaHCO<sub>3</sub> with HCl. Vigorous bubbling will occur, and when heating the contents of the test tube it will have a tendency to "shoot out." Be sure to move the test tube slowly in and out of the flame, while cautiously shaking the test tube. Always keep the test tube in a slanted position to expose the maximum

area of the contents to heating. *Do not* point the open end of the test tube at anyone (including yourself!).

#### PROCEDURE

**NOTE:** Use a milligram balance for all measurements. Record data to the nearest 0.001 g.

- **A.** Place a clean and dry  $18 \times 150$ -mm test tube in a beaker. Weigh this "container" and record its mass on the work page.
- **B.** Add about 0.25–0.35 g of sodium hydrogen carbonate, NaHCO<sub>3</sub>, to the test tube. Weigh the beaker, test tube, and contents. Record the mass.
- **C.** One drop at a time, cautiously add 3 M hydrochloric acid, HCl, to the test tube. After each addition, gently shake the test tube until the reaction stops. Continue adding acid until there is no evidence of any further reaction (no more bubbles form). At this point no more solid should be present.
- **D.** Evaporate all fluid by slowly moving the test tube in and out of the flame. Remember to keep the test tube slanted and shake it gently. Proceed until all liquid has evaporated.
- E. Remove the test tube from the flame and test for water vapor by inverting a clean and dry test tube over the mouth of your test tube. If you see condensation, heat the test tube for an additional 5 minutes and test again. Alternatively, after the contents of the test tube appear dry, place the test tube in a 110–120°C oven and heat for 20 minutes.
- **F.** Cool the test tube to room temperature. Place the test tube in the beaker used for earlier weighing and determine the mass.

#### CALCULATIONS

Using only numbers from your measurements, calculate by difference the initial mass of the sodium hydrogen carbonate. From the final weighing, calculate by difference the mass of the sodium chloride. From these quantities, using appropriate molar masses, calculate the number of moles of each compound.

$$Moles = \frac{mass (g)}{molar mass (g/mole)}$$
 (11.2)

Calculate the mole ratio of NaHCO<sub>3</sub> to NaCl. Compare this value to the theoretical value. Calculate the percent error (see Experiment 4).

Name Date Section

## **Experiment 11**

### **Advance Study Assignment**

1. In the laboratory a student carried out the reaction

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2 \\$$

The following data were collected:

Mass of container 48.365 g

Mass of container + CaCO<sub>3</sub> 48.638 g

Mass of container + contents after evaporation of the liquid 48.664 g

Based on the data above, calculate:

a. Starting mass of CaCO<sub>3</sub>

**b.** Mass of CaCl<sub>2</sub> obtained

c. Mole ratio of CaCO<sub>3</sub> to CaCl<sub>2</sub>

**2.** List possible sources of error in this experiment.

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Name	Date	Section
Experiment 11		
Work Page		
Mass Data		
Mass of container (g)		
Mass of container + NaHCO <sub>3</sub> (g)		
Mass of container + NaCl (g) 1st heating		
Mass of container + NaCl (g) 2nd heating		
Results		
Mass of NaHCO <sub>3</sub> (g)		
Mass of NaCl (g)		
Calculations		
1. Moles of NaHCO <sub>3</sub> and NaCl:		
2. Mole ratio:		
<b>3.</b> How does your experimental ratio compare might have caused the difference.	to the theoretical? If t	hey are different, explain what
<b>4.</b> Calculate the percent error.		

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Name		Section
Evnoriment 11		
Experiment 11 Report Sheet		
Report Sheet		
Mass Data		
Mass of container (g)		
Mass of container + NaHCO <sub>3</sub> (g)		
Mass of container + NaCl (g) 1st heating		
Mass of container + NaCl (g) 2nd heating		
Results		
Mass of NaHCO <sub>3</sub> (g)		
Mass of NaCl (g)		
Calculations		
1. Moles of NaHCO <sub>3</sub> and NaCl:		
2. Mole ratio:		
<b>3.</b> How does your experimental ratio compare to might have caused the difference.	the theoretical? If the	ney are different, explain what
4. Calculate the percent error.		

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