FLINN SCIENTIFIC

Name____

Supplementary Material

Determining the Stoichiometry of a Chemical Reaction

Background

A balanced chemical equation gives the mole ratios of reactants and products for a chemical reaction. If the formulas of all reactants and products are known, it is relatively easy to balance an equation to find out what these mole ratios are. When the formulas of the products are not known, experimental measurements must be made to determine the ratios.

This laboratory uses the method of continuous variation to determine the mole ratio of two reactants. Several steps are involved. First, solutions of the reactants are prepared in which the concentrations are known. Second, the solutions are mixed a number of times using different ratios of reactants. Third, some property of the reaction that depends on the amount of product formed or on the amount of reactant that remains is measured. This property may be the color intensity of a reactant or product, the mass of a precipitate that forms, or the volume of a gas evolved.

In the method of continuous variation, the total number of moles of reactants is kept constant for the series of measurements. Each measurement is made with a different *mole ratio* of reactants. The optimum ratio, which is the *stoichiometric ratio* in the equation, should consume the greatest amount of reactants, form the greatest amount of product, and, if the reaction is exothermic, generate the most heat and maximum temperature change.

In this laboratory, the amount of precipitate formed in a *double replacement reaction* is the property that will be measured. Seven different mole ratios of reactants are combined in 50-mL graduated cylinders. The volume of precipitate formed for each mole ratio is measured and these volumes are plotted versus the mole ratio.

Materials

Potassium chromate solution, K_2CrO_4, 0.5 M, 210 mL

Silver nitrate solution, $AgNO_3$, 0.5 M, 210 mL

Marker or labeling pen

Graduated cylinders, 50-mL, 2

Graduated cylinders, 100-mL, 7

Stirring rods, long, 2

Safety Precautions

Potassium chromate is a known carcinogen and its solutions are corrosive to skin and eyes and are moderately toxic by ingestion. Avoid contact with eyes and skin. Silver nitrate solution is moderately toxic and will stain 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.

Disposal

Review all federal, state and local regulations that may apply before proceeding. All solid chromate compounds and solutions must be saved for disposal by a licensed waste disposal company.

Procedure

Reaction of Silver Nitrate with Potassium Chromate

1. Label seven 100-mL graduated cylinders 1–7.
2. Using a clean, 50-mL graduated cylinder, add the appropriate volume of silver nitrate solution to each 100-mL graduated cylinder, as shown in Table 1.
3. Use a second 50-mL graduated cylinder to add the appropriate volume of potassium chromate solution to each 100-mL graduated cylinder, as shown in the data table.

4. Use a large stirring rod to thoroughly mix the reactants. Observe the signs of chemical reaction in each cylinder. (Mixing the clear solution of silver nitrate with the yellow potassium chromate solution gives a rust-colored precipitate and a pale yellow supernatant.)
5. Let the reaction mixtures sit undisturbed for at least 10 minutes to allow the precipitates to settle.
6. After the precipitates have settled, record the volume of precipitate in each graduated cylinder in the Data Table.
7. Collect the waste in the hood as directed by the instructor—chromium compounds are heavy metals and require licensed hazardous waste disposal.

Data Table

Cylinder	**1**	**2**	**3**	**4**	**5**	**6**	**7**
$AgNO_3$, 0.5 M, mL	10	15	20	30	40	45	50
K_2CrO_4, 0.5 M, mL	50	45	40	30	20	15	10
Ag:CrO_4 Mole Ratio	1:5	1:3	1:2	1:1	2:1	3:1	5:1
Precipitate, mL							

Analysis

1. On graph paper, plot the milliliters of reactant #1 versus volume of precipitate for each reaction. Draw the two best-fit straight lines through the data points and determine their point of intersection.
2. From the point of intersection, determine the stoichiometric mole ratio for the reaction. Write out the correct balanced equation for the reaction.

AP Chemistry Review Questions

Integrating Content, Inquiry and Reasoning

1. Calculate the theoretical mass of sodium carbonate solid that should be produced by heating 1.678 g of sodium bicarbonate.

2. If 1.018 g of sodium carbonate were produced from the sodium bicarbonate in Question 1, calculate the percent yield for the bicarbonate decomposition reaction.

3. Calculate the mass of water vapor and carbon dioxide that would be produced by gently heating a mixture of 1.550 g of sodium bicarbonate and 0.463 g of sodium carbonate. What mass of sodium carbonate would remain in the crucible?

4. A classic high school lab experiment involves combining a solution of barium nitrate, $Ba(NO_3)_2$, with a sodium sulfate solution, Na_2SO_4, forming a precipitate of barium sulfate.

$$Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$$

   a. Identify the hazards associated with the chemicals in this reaction.

   b. The purpose of this lab is to teach the techniques and principles of quantitative gravimetric analysis. Use your knowledge of solubility products to devise a greener set of solutions that would meet the purpose of this lab.