

DETERMINE THE MOLE RATIOS IN A CHEMICAL REACTION



Westminster College

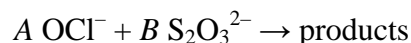
LAB ADV COMP.9

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INTRODUCTION

A balanced chemical reaction equation gives the mole ratios of the reactants and the products as coefficients. When some of the chemical formulas are not known, an experiment must be conducted to help determine the mole ratios.

This experiment uses two common substances as the reactants: hypochlorite ion (OCl^-) from household bleach and thiosulfate ion ($\text{S}_2\text{O}_3^{2-}$), the active ingredient in a photographic “fixer” solution used to develop film. In the reaction, hypochlorite ions oxidize the thiosulfate ions according to the unbalanced and incomplete reaction equation below.

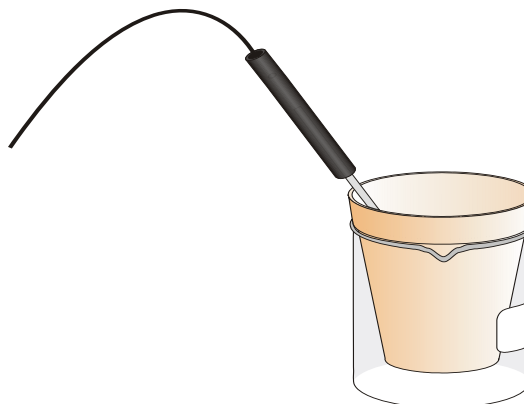


It is possible to identify the coefficients, A and B , for the reactants, without knowing the products of the reaction. The process that you will use to determine the coefficients is called *continuous variations*. You will prepare a series of mixtures of the two reactants. Each mixture will have the same total volume and the same total number of moles of reactants. The reaction is exothermic, thus the mixture that generates the most heat energy will be the reaction that completely consumes both the hypochlorite and the thiosulfate ions. As heat energy is a product of this reaction, the reaction ratio that produces the most heat indicates the stoichiometry of the reaction. You will use this mixture to establish the coefficients, and therefore the mole ratio, for the reaction.

OBJECTIVES

In this experiment, you will

- Measure the enthalpy change of a series of reactions.
- Determine the stoichiometry of an oxidation-reduction reaction in which the reactants are known but the products are unknown.



MATERIALS

LabQuest	three 250 mL beakers
LabQuest App	0.50 M sodium hypochlorite, NaOCl, solution
Temperature Probe	0.50 M sodium thiosulfate, Na ₂ S ₂ O ₃ , solution in
two 10 mL graduated cylinders	0.2 M sodium hydroxide, NaOH
two 25 mL graduated cylinders	Styrofoam® cups
two 50 mL graduated cylinders	

PROCEDURE

1. Obtain and wear goggles.
2. Connect the Temperature Probe to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
3. Tap the Mode: box on the LabQuest and then tap on the length box. A keyboard should appear on the screen. Using the backspace key remove 180 and then enter 90 for the length of the experiment. Tap Ok.
4. Measure out precisely 25.0 mL of the 0.50 M NaOCl solution. Pour this solution into a Styrofoam cup and nest the cup in a beaker to help stabilize the cup.
5. Immerse the tip of the Temperature Probe in the Styrofoam cup of NaOCl solution.
6. Measure out precisely 25.0 mL of the 0.50 M Na₂S₂O₃ solution. **Note:** Do not mix the two solutions yet.
7. Start data collection. Let the program gather and graph a few initial temperature readings, and then add the Na₂S₂O₃ solution. Gently stir the reaction mixture with the Temperature Probe.
8. Data collection will stop after 3 minutes. You may stop data collection before three minutes have passed if the temperature readings are no longer changing. Examine the graph by selecting any data point to trace the graph. Calculate and record the maximum temperature change.
9. Rinse out and dispose of the reaction mixture as directed.
10. Repeat the necessary steps to continue testing various ratios of the two solutions, keeping the total volume at 50.0 mL. Use the data table for the desired volumes of each reagent and record the temperature change for each trial
11. Restart the LabQuest by tapping the play icon and then tapping discard to clear the previous data set.
12. The trial with the greatest temperature change will be the optimal reaction ratio.

DATA TABLE

Volume OCl^-	Volume $\text{S}_2\text{O}_3^{2-}$	Reaction Ratio	Initial Temperature	Maximum Temperature	Temperature Change
25.0 mL	25.0 mL				
16.7 mL	33.3 mL				
33.3 mL	16.7 mL				
12.5 mL	37.5 mL				
37.5 mL	12.5 mL				
10.0 mL	40.0 mL				
40.0 mL	10.0 mL				

DATA ANALYSIS

1. Determine the whole number mole ratio of the two reactants.
2. The molarities of the reactant solutions were equal in this experiment. Is this necessary, or even important, for the success of the experiment?
3. Which solution was the limiting reactant in each trial?
4. Find the actual balanced chemical equation for the reaction between OCl^- and $\text{S}_2\text{O}_3^{2-}$. Does the mole ratio that you determined in your experiment match the actual reaction equation's coefficients for the two reactants? Explain, especially if your mole ratios do not match the coefficients.