The Ratio That Creates Large Amount of Heat Energy

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Objective

The objective of this experiment is to find the ratio that creates a large amount of heat energy that wholly utilizes substance ions, such as thiosulfate ion ($S_2O_3^{2-}$) and hypochlorite ion (OCl^-). After this, the equation will be balanced by using the coefficient that develops the mole ratio for the particular reaction.

Introduction

A balanced chemical equation plays a significant role in providing mole ratios of reactants as well as products, with the products as the coefficients which balance the equation. It becomes easier to balance the chemical equation once all formulas of reactants and products are well-known. A mole ratio determines how many moles of each chemical are to be used in a reaction to make it balanced and limits the amount of a limiting or excess reagent. Limiting reagents are the reactants that run out first and limit the amount of product that can form, and an excess reagent is a reactant that there is more than enough of to form a product and is often what is left after the reaction. Experimental measures can be utilized to make ratios when the formula of products is unknown. An example of an unbalanced and incomplete reaction is A $OCL^-_{(aq)}$ + B $S_2O_4^{2-}{}_{(aq)}$ → products. A and B are the moles or coefficients that are needed for each compound to balance the equation. Measuring this heat to find the maximum temperature that will cause a reaction that completely consumes both ions, leaving behind no excess or a limiting reagent, will give you the mole ratio for this reaction.

Materials:

For this experiment, the materials needed were Logger Pro software on a computer and a LabPro data logger to collect information with a temperature probe. Other items that needed to be obtained were two 10-mL and two 25-mL graduated cylinders and Styrofoam cups. Also needed would be three 250 mL beakers to pour the solutions into and to give the cup extra stability. 0.5 molar solution of $Na_2S_2O_3$ and 0.5 M solution of NaOCl in 0.2 molar solution of NaOH will be collected.

Procedure:

After the computer and all of the equipment were set up and logged in to LoggerPro, the file “07 was opened. After a pair of goggles to wear were collected, the 50 mL of each of the reactant solutions, NaOCl and Na2S2O3, were placed in clearly labelled separate beakers. Exactly five ml solution of NaOCl was measured and put into the cup. The Styrofoam cup was placed inside a beaker for the purpose of stability. The temperature probe was placed in the solution of NaOCl, and then the “Collect” button was selected to begin collecting data from the initial temperature forward. The 0.5 mL of $Na_2S_2O_3$ was added. After the introduction of $Na_2S_2O_3$, the mixture was stirred continuously with the temperature probe. When the temperature readings from the data were no longer changing, the “Stop” button was clicked, and the maximum temperature change was recorded and determined. By using the Statistics button in LoggerPro, the minimum and maximum temperatures were found on the graph. After rinsing the cup and disposing of the solution into the waste bottle in the fume hood, the experiment was repeated, testing different ratios of the two solutions, and this would be repeated several times. The second trial used 6 mL of NaOCl and 4 mL of $Na_2S_2O_3$, as the total volume was always 10 mL to have constant results. The remaining trials used ratios of 3.0 mL $Na_2S_2O_3$ and 7.0 mL of NaOCl, 6.0 mL of Na2S2O3 with 8 mL of NaOCl, and 7 mL of $Na_2S_2O_3$ solution and 3 mL of NaOCl. Other used ratios include 2 mL $Na_2S_2O_3$ with 8 mL of NaOCl, 2.5 mL $Na_2S_2O_3$ solution and 7.5 mL of NaOCl solution, 1 mL of $Na_2S_2O_3$ solution, and 9 mL of NaOCl.

The highlighted data was the data surrounding the highest temperature change recorded. The max change would occur between 7.5 mL of NaOCl and 8 mL of NaOCl. The ratio of 8:2 is the same as 4:1 for the maximum and thus the perfect ratio as there were not any limiting or excess reagents.

Results And Discussion:

As the trials were being performed to find the perfect ratio the temperatures had a steady increase. Looking at the highest temperature on the graph, it was determined that the maximum reading was at a ratio of 8.0 mL of NaOCl and 2.0 $Na_2S_2O_3$ with a temperature of 17.99°C. This ratio of 8:2 can be simplified to 4:1 and was shown on the graph as an intersection point. The ratio of 9:1 proved to give a much lower temperature than was expected, with 10 mL of NaOCl having a temperature change of 0°C. When OCl was less than 8 mL, it was the limiting reagent, but when it was greater than 8 mL, S_2O_3 was the limiting reagent. (Flowers et al., 2019)

If the concentrations of these solutions were different, then they would have reacted differently, as a base reacts with an acid. (Ling et al., 2016)

The true balanced equation is 4OCl + S2O3 = 4Cl + SO3 +SO2 +O2. This follows our ratio of 4:1. (National Institute of Standards and Technology, n.d.)

References

Flowers, P., Theopold, K., Langley, R., & Robinson, W. R.. (2019). *Chemistry 2e*. OpenStax. https://openstax.org/books/chemistry-2e/pages/1-introduction

Ling, S. J., Moebs, W., & Sanny, J.. (2016). *University physics volume 2*. OpenStax. https://openstax.org/books/university-physics-volume-2/pages/1-introduction

National Institute of Standards and Technology. (n.d.). NIST Chemistry WebBook. https://webbook.nist.gov/chemistry/