Titration of a Bleach Solution

Objectives

The purpose of this experiment is to determine the concentration of sodium hypochlorite in a commercial bleach solution and compare the experimental value to that listed on the container of bleach.

Safety Precautions

Liquid bleach is corrosive and must be handled with care. Any spill on your body or in your eyes must be washed with water immediately.

Introduction

Two of the most common types of reactions are acid-base reactions and oxidation-reduction (redox) reactions. It is not surprising that such reactions are the basis for many analytical procedures used to determine the amounts of substances in certain samples. An oxidation-reduction titration involves the addition of a solution of either an oxidizing agent or reducing agent to a solution of a reducing agent or oxidizing agent. One of these solutions has a known concentration while the other is unknown. The solutions are added until the stoichiometric amounts of oxidizing and reducing agents have been combined. The oxidizing agent in liquid bleach is sodium hypochlorite. To determine its concentration, it will be added to a solution of potassium iodide in order to produce iodine which is then titrated with a solution of sodium thiosulfate of known concentration. There are two reactions which will take place. First the sodium hypochlorite will react with the potassium iodide, this reaction requires acidic conditions to take place. The chlorine in the hypochlorite ion is reduced to chloride ion, the iodide ion is oxidized to iodine. (1)

$$2\ HCl(aq) + 2\ KI(aq) + NaOCl(aq) \rightarrow I_2(aq) + NaCl(aq) + H_2O + 2\ KCl\ (aq) \qquad (1)$$

After the iodine is made in reaction (1), it is reduced back to the iodide ion by the sodium thiosulfate as shown in the following equation (2).

$$I_2(aq) + 2\ Na_2S_2O_3(aq) \rightarrow 2\ NaI(aq) + Na_2S_4O_6(aq) \qquad (2)$$

Often oxidation reduction reactions are written in the form of net ionic equations, (3), (4)

$$2\ H^+(aq) + 2\ I^-(aq) + OCl^-(aq) \rightarrow I_2(aq) + Cl^-(aq) + H_2O \qquad (3)$$

$$I_2(aq) + 2\ S_2O_3^{2-}(aq) \rightarrow 2\ I^-(aq) + S_4O_6^{2-}(aq) \qquad (4)$$

The number of moles of sodium thiosulfate that have been added at the end point equals twice the number of moles of iodine as seen in equation (2). From equation (1) it can be seen that the number of moles of iodine equals the number of moles of sodium hypochlorite. Since most liquid bleaches report the concentration of sodium hypochlorite in terms weight/weight percent, the density of the commercial bleach solution must be determined. You will then use the calculated molarity of the sodium hypochlorite, molar mass of sodium hypochlorite and density of the bleach solution to calculate the weight/weight percent of sodium hypochlorite in bleach. See the following sample calculation.

Sample Calculation.

What is the molarity of NaOCl in a solution of bleach if 10.00 mL requires 22.35 mL of 0.02191 M $Na_2S_2O_4$ to reach the endpoint?

$$22.35\ \text{mL} \times \frac{0.02191\ \text{mol } Na_2S_2O_4}{1000\ \text{mL}} \times \frac{1\ \text{mol } I_2}{2\ \text{mol } Na_2S_2O_4} \times \frac{1\ \text{mol NaOCl}}{1\ \text{mol } I_2} = 0.0002448\ \text{mol NaOCl}$$

$$\frac{0.0002448\ \text{mol NaOCl}}{0.01000\ \text{L}} = 0.02448\ \text{M NaOCl}$$

What is the molarity of commercial bleach if 3.00 mL has been diluted to a volume of 100.0 mL with water? The concentration of the diluted bleach is 0.02448 M.
You may use the equations $M_{conc} V_{conc} = M_{dil} V_{dil}$

$$M_{conc} = M_{dil} V_{dil} / V_{conc} = (0.02448\ \text{M})(100.0\ \text{mL}) / 3.00\ \text{mL} = 0.8160\ \text{M}$$

What is the concentration, in weight/weight percent of NaOCl in the commercial bleach? The density of the bleach sample is 1.056 g/mL and the molarity of NaOCl in the commercial bleach is 0.8160 M.

$$\frac{0.8160\ \text{mol NaOCl}}{1000\ \text{mL bleach}} \times \frac{74.44\ \text{g NaOCl}}{1\ \text{mol NaOCl}} = \frac{0.06074\ \text{g NaOCl}}{1\ \text{mL bleach}} \times \frac{1\ \text{mL}}{1.056\ \text{g}} = \frac{0.05752\ \text{g NaOCl}}{1\ \text{g bleach}}$$

$$\frac{0.05752\ \text{g NaOCl}}{1\ \text{g bleach}} \times 100 = 5.752\ \%$$

Procedure

Your grade will depend in part on the accuracy and precision of your results.

A. Density of Original Bleach Solution

1. Record the brand of bleach.
2. Weigh an empty Erlenmeyer flask on an analytical balance to the 4th decimal place.
3. Pipet into the Erlenmeyer flask 25 mL of the commercial bleach (not the dilute solution of the bleach).
4. Weigh the Erlenmeyer flask with the bleach on an analytical balance.

B. Titration of a Dilute Solution of Bleach

You will titrate a dilute solution of the commercial bleach. This dilute solution has been prepared by diluting 3.00 mL of commercial bleach to 100.0 mL.

1. Prime a 10-mL pipet with the dilute solution of bleach.
2. Prime a 25-mL buret with a standard solution of sodium thiosulfate. Fill the primed buret with sodium thiosulfate solution and drain to the 0.00 mL mark or below and record this initial reading of the buret.
3. Record the concentration of the sodium thiosulfate.
4. Pipet 10.00 mL of the dilute bleach solution into a 125-mL Erlenmeyer flask.
5. Add about 1 cm^3 of potassium iodide to the dilute bleach, along with 25 mL water and 1 mL of 2M hydrochloric acid. A dark red solution should be formed.
6. Titrate the sodium thiosulfate into the Erlenmeyer flask until the solution turns pale yellow. Add 1 mL of 0.2% starch solution and continue titrating until the blue color turns colorless.
7. Record the final reading of the buret.
8. Repeat steps 4 - 7 until the precision is 0.6% r.s.d. or less. Show your calculation of % r.s.d. in your lab record book.

Titration of a Bleach Solution

Name _____ Section _____ Date _____

Data and Calculations Show calculations in space provided or on a separate sheet of paper.

A. Density of Commercial Bleach

1. Mass of Erlenmeyer flask _____
2. Volume of bleach added to Erlenemeyer flask 25.00 mL
3. Mass of Erlenmeyer flask and bleach _____
4. Density of commercial bleach (mass ÷volume) _____

B. Concentration of Dilute Bleach Solution

1. Record the volumes of sodium thiosulfate solution used in the titration trials.

   Trial 1. _____ Trial 2. _____ Trial 3. _____

   Trial 4. _____ Trial 5. _____ Trial 6. _____
2. Record the concentration of the sodium thiosulfate. _____
3. Calculate the average volume of thiosulfate used in all trials. _____
4. Molarity of dilute bleach _____

5. Molarity of Commercial Bleach _____

6. Percent (w/w) of Commercial Bleach= _____

   % NaOCl listed on the label = _____ % Error = _____