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Experiment 33
Analysis of an Oxygen Bleach

Learning Objectives: By the end of this experiment, the student should be able to demonstrate the following proficiencies:

1. Identify and use the following equipment: buret, pipet, Erlenmeyer flask, volumetric flask.
2. Perform a redox titration and consistently reach the endpoint.
3. Balance redox equations.
4. Use the stoichiometry from a redox reaction to calculate the mass percent of H_2O_2 in an oxygen bleach.
5. Explain what environmental advantage an oxygen bleach has over a chlorine bleach.

Purpose: The purpose of this experiment is two fold: (1) to standardize a $KMnO_4$ solution; (2) to use the standardized $KMnO_4$ solution to determine the amount of H_2O_2 present in an oxygen bleach by means of a titration.

Introduction:

A bleach is an oxidizing agent; that is, a molecule that can readily undergo reduction, causing something else (dirt, stains) to be oxidized and hence destroyed. The most common type of laundry bleach is "chlorine" bleach, in which the active ingredient is the hypochlorite ion, OCl^-. Reduction of hypochlorite in solution occurs according to the reaction

$$2\,e^- + H_2O_{(l)} + OCl^-_{(aq)} \rightarrow Cl^-_{(aq)} + 2\,OH^-_{(aq)} \qquad (1)$$

In "non-chlorine" or "oxygen" bleach, the bleaching agent is hydrogen peroxide, H_2O_2. In this experiment you will analyze the hydrogen peroxide content of an "oxygen" bleach.

The UNBALANCED equation, in acidic solution, for the reaction you will use is:

$$_____\ H_2O_{2\,(aq)} + _____\ MnO_4^-{}_{(aq)} \rightarrow _____\ O_{2\,(g)} + _____\ Mn^{2+}{}_{(aq)} \qquad (2)$$

The first step in this experiment involves the use of an H_2O_2 solution. Since H_2O_2 solutions are not very stable over time, you will make a fresh solution that contains H_2O_2 in a seemingly indirect way. This is done by weighing out a known amount of sodium perborate ($NaBO_3{\cdot}4H_2O$) solid and dissolving it in water. Sodium perborate rapidly reacts with water to produce H_2O_2 by the reaction:

$$2\,H_2O_{(l)} + BO_3^-{}_{(aq)} \rightarrow H_2O_{2\,(aq)} + H_2BO_3^-{}_{(aq)} \qquad (3)$$

Thus from the mass of $NaBO_3{\cdot}4H_2O$ solid used, one can determine the amount of H_2O_2 in solution.

The H_2O_2 solution of known concentration (made by using $NaBO_3{\cdot}4H_2O$) will then be used to titrate a $KMnO_4$ solution of unknown concentration. This process of finding the concentration of the $KMnO_4$ solution is called standardization. Once the $KMnO_4$ solution is standardized, it can be used to titrate the oxygen bleach so that a mass % of H_2O_2 in the bleach can be reported. It is important to note that both the standardization and the bleach sample analysis are governed by the BALANCED form of equation (2) above (recall #1 in the pre-lab exercises).

You will find that the titrations in this experiment have some interesting chemistry associated with them. Since $MnO_4^-{}_{(aq)}$ is a purple colored ion, it can serve as its own equivalence point indicator in the titrations performed. For example, in the titration of the bleach solution in Part III., as long as H_2O_2 is present in the flask, the purple color of $MnO_4^-{}_{(aq)}$ ion will not appear. However, one drop of excess $KMnO_4$ solution (beyond the equivalence point) will cause the solution to take on a permanent purple color of $MnO_4^-{}_{(aq)}$.

Another interesting feature of this titration is that the reaction taking place is auto-catalyzed. This means that a product of the redox reaction catalyzes the reaction. This is why the reaction is slower at the start of the titration but very rapid as you approach the equivalence point.

Procedure:

Part I. Preparation of standard H_2O_2 solution:
(NOTE: Take care not to get any of this solution on your uniform).

1. Prepare 250.00 mL of 0.030 M H_2O_2 by weighing out _____ g of $NaBO_3 \cdot 4H_2O$ and transferring it to a 250 mL beaker. Be sure to rinse (with distilled water) all of the solid from the weighing boat into the beaker and to record the actual mass of solid used in the Data Record.

2. Pre-dissolve the solid by adding 100 mL of distilled water and 50 mL of 1.0 M H_2SO_4 to the beaker and stirring the solution with a glass rod.

3. Quantitatively transfer this solution to a 250.00 mL volumetric flask and dilute to the mark with distilled water. Thoroughly mix the contents of the flask by inverting it several times.

Part II. Standardization of the $KMnO_4$ solution:
(NOTE: Be careful not to get the $KMnO_4$ solution on your skin as it will turn your skin brown.)

1. Pipet 25.00 mL of the $KMnO_4$ solution provided into a 250 mL Erlenmeyer flask.

2. Add 20 mL of 1.0 M H_2SO_4 to this flask.

3. Fill a 50 mL buret with the H_2O_2 solution prepared in Part I. Record the initial volume from the buret.

4. Place a white tissue under the flask and titrate the $KMnO_4$ solution in the flask with the H_2O_2 solution. Record the final volume from the buret.

5. Repeat steps #1-4 until you get two results that are in good agreement (within ~0.5 mL of H_2O_2 solution used).

Part III. Titration of bleach solution:
(NOTE: Take care not to get any of the bleach solutions on your uniform).

1. Dilute the *Seventh Generation Non-Chlorine Bleach* by pipeting 5.00 mL of bleach into a 100.00 mL volumetric flask and fill the flask to the mark with distilled water. Thoroughly mix the contents of the flask by inverting it several times.

2. Pipet 10.00 mL of the diluted bleach solution into a 250 mL Erlenmeyer flask.

3. Add 20 mL of 1.0 M H_2SO_4 to the flask.

4. Fill a 50 mL buret with the $KMnO_4$ solution provided. Record the initial volume from the buret.

5. Titrate the bleach solution in the Erlenmeyer flask with the $KMnO_4$ solution. Record the final volume from the buret.

6. Repeat steps #2-5 until you get two results that are in good agreement (within ~ 0.5 mL of $KMnO_4$ solution used).

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Data Record

Part I. Preparation of $NaBO_3 \cdot 4H_2O$ solution:

mass of $NaBO_3 \cdot 4H_2O$ used _____

Part II. Standardization of the $KMnO_4$ solution:

	Trial #1	Trial #2	Trial #3
initial buret reading	_____	_____	_____
final buret reading	_____	_____	_____
volume of H_2O_2 solution used	_____	_____	_____

Part III. Titration of bleach solution:

	Trial #1	Trial #2	Trial #3
initial buret reading	_____	_____	_____
final buret reading	_____	_____	_____
volume of $KMnO_4$ solution used	_____	_____	_____

Data Treatment

Parts I and II. Preparation and Titration of standard H_2O_2 solutions:

1. Calculate the molarity of the H_2O_2 solution prepared in Part I from the **actual mass of $NaBO_3 \cdot 4H_2O$ used** and the stoichiometry of equation (3). (Show calculation.)

2. Using the molarity of the H_2O_2 solution calculated in 1. above and the stoichiometry of the BALANCED form of equation (2), calculate the molarity of the $KMnO_4$ solution from each trial in Part II. (Recall that the volume of $KMnO_4$ titrated was 25.00 mL). (Show one sample calculation).

Molarity of $KMnO_4$ from Trial #1 _____ Molarity of $KMnO_4$ from Trial #3 _____

Molarity of $KMnO_4$ from Trial #2 _____

Average molarity of $KMnO_4$ solution _____

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Part III. Titration of bleach solutions:

1. Calculate the moles of H_2O_2 in the bleach sample tested in each trial. Use the *average molarity* of the $KMnO_4$ in these calculations. (Show calculation for Trial #1)

Moles H_2O_2 from Trial #1 _____ Moles H_2O_2 from Trial #3 _____

Moles H_2O_2 from Trial #2 _____

2. Assuming that the density of the bleach solution is 1.00 g/mL, calculate the **mass of full strength bleach tested** in each trial in Part III. *NOTE*: Remember to factor in the dilution made in Step 1 of Part III. (Show calculation)

Mass of full strength bleach tested in Trial #1 _____ Mass of full strength bleach tested in Trial #3 _____

Mass of full strength bleach tested in Trial #2 _____

3. Calculate the mass % of H_2O_2 in the full strength bleach solution. (Show calculation for Trial #1).

Mass % H_2O_2 in bleach from Trial #1 _____ Mass % H_2O_2 in bleach from Trial #3 _____

Mass % H_2O_2 in bleach from Trial #2 _____

Average mass % H_2O_2 in bleach _____

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Pre-lab Exercises

1. Balance equation (2) on page 1. (in acidic solution) in the space below. RECORD THE COEFFICIENTS OF THE BALANCED EQUATION IN THE SPACES PROVIDED IN EQUATION (2) ON PAGE 1.

2. Calculate the mass of $NaBO_3 \cdot 4H_2O$ needed to make 250.00 mL of a 0.030 M H_2O_2 solution. RECORD YOUR ANSWER IN STEP ONE OF PART I. OF THE PROCEDURE ON PAGE 2.

3. What environmental advantage does an oxygen bleach have over a chlorine bleach? (Use the Internet and cite your source as part of your answer.)