Experiment 4D

4/2/19

STOICHIOMETRY DETERMINATION FOR THE REACTION OF HYDROGEN PEROXIDE AND POTASSIUM PERMANGANATE

MATERIALS: 250 mL volumetric flask with stopper, 50 mL buret, buret funnel, 250 mL Erlenmeyer flask, 100 mL graduated cylinder, 50 mL graduated cylinder, 100 mL beaker, 25.00 mL pipet, weighing dish, 1.0 M H_2SO_4, 0.01 M $KMnO_4$, $NaBO_3{\cdot}4H_2O$

PURPOSE: The purpose of this experiment is two-fold: (1) to accurately prepare a 250.0 mL solution of 0.0300M hydrogen peroxide; (2) to use the hydrogen peroxide solution to titrate a solution of potassium permanganate of known molarity, to determine the stoichiometry of the reaction.

LEARNING OBJECTIVE: By the end of this experiment, the midshipman should be able to demonstrate the following proficiencies:

1. Use pipets and burets correctly.
2. Accurately make up a solution of known molarity.
3. Perform a titration accurately and precisely.
4. Calculate the molarity of a solution.
5. Determine the stoichiometry for a reaction.

DISCUSSION:

There are two possible ways to balance the following reaction equation:

$$\_\_\ H_2O_2(aq) + 2\ KMnO_4(aq) + 3\ H_2SO_4(aq) \rightarrow \_\_O_2(g) + 2\ MnSO_4(aq) + K_2SO_4(aq) + \_\_H_2O(\ell)$$

The stoichiometry can be determined by titrating a known amount of hydrogen peroxide with a solution of potassium permanganate of known molarity.

Hydrogen peroxide solutions are so unstable that they decompose quickly. Therefore, a hydrogen peroxide solution has to be prepared at the time it is to be used, by reacting sodium perborate tetrahydrate, $NaBO_3{\cdot}4H_2O$, with water:

$$NaBO_3{\cdot}4H_2O\ (s)\ +\ 2\ H_2O\ (\ell)\ \rightarrow\ H_2O_2\ (aq)\ +\ NaH_2BO_3\ (aq)\ +\ 4\ H_2O\ (\ell)$$

PROCEDURE:

Part A. Preparation of the Hydrogen Peroxide Solution

1. Use the top-loading balance to pre-weigh between 1.13 and 1.17 grams of $NaBO_3 \cdot 4H_2O$ into a weighing dish.

2. Use the analytical balance to obtain the mass of the weighing dish and the $NaBO_3 \cdot 4H_2O$ sample. *Quantitatively transfer* the $NaBO_3 \cdot 4H_2O$ to a clean 250.0 mL volumetric flask. (A qualitative transfer is a complete transfer of the sample between containers with no spills.) Obtain the mass of the empty weighing dish.

3. To the volumetric flask with $NaBO_3 \cdot 4H_2O$, add about 100 mL of distilled water and 50 mL of 1.0 M H_2SO_4. Insert a stopper and mix well by inverting the flask several times until the $NaBO_3 \cdot 4H_2O$ is completely dissolved. Add distilled water to the mark.

Part B. Titration of Hydrogen Peroxide with Potassium Permanganate

1. Pipet 25.00 mL of H_2O_2 solution into a 250-mL Erlenmeyer flask. Add about 20 mL of 1.0 M H_2SO_4. Swirl to mix well.

2. Put 50 mL of $KMnO_4$ in a 100 mL beaker. Record its molarity. Pour the $KMnO_4$ solution from the beaker, through a funnel into the buret.

3. Titrate the H_2O_2 solution with $KMnO_4$ until a very pale (purple) pink color appears and remains for at least 20 seconds.

4. Repeat this process. If two titrations are not within +/- 0.50 mL of each other, repeat this process again.

Clean up:

1. Dispose of solution obtained from titration, any unused hydrogen peroxide solution, any unused potassium permanganate solution, in the appropriately labeled waste containers under the instructor's hood.

2. Wash all glassware. Invert the buret and mount it in the buret clamp on the ring stand, with the stopcock open to allow it to drain. Leave the other washed glassware upright.

Name_____ Section_____

Partner_____ Date_____

DATA SECTION
Experiment 4D

INCLUDE THE APPROPRIATE SIGNIFICANT FIGURES.

Part A. Preparation of the Hydrogen Peroxide Solution

Mass of weighing dish + $NaBO_3 \cdot 4H_2O$ (g)	
Mass of weighing dish (g)	
Mass of $NaBO_3 \cdot 4H_2O$ (g)	
Volume of H_2O_2 prepared (mL)	250.0

Part B. Titration of Hydrogen Peroxide with Potassium Permanganate

	Sample 1	Sample 2	Sample 3
Volume of H_2O_2 titrated (mL)	25.00	25.00	25.00
Molarity of $KMnO_4$ on bottle (M)			
Initial buret reading of $KMnO_4$ (mL)			
Final buret reading of $KMnO_4$ (mL)			
Volume of $KMnO_4$ used (mL)			

Need 2 good titrations within +/- 0.50 mL

DATA TREATMENT
Experiment 4D

INCLUDE THE APPROPRIATE SIGNIFICANT FIGURES.

Part A. Preparation of the Hydrogen Peroxide Solution

(A.1) Calculate the concentration (M, molarity) of the H_2O_2 solution:

Part B. Titration of Hydrogen Peroxide with Potassium Permanganate

(B.1) Calculate the moles of H_2O_2 in 25.00 mL:

(B.2) Calculate the moles of potassium permanganate, $KMnO_4$, for:

Sample 1:

Sample 2:

Sample 3:

(B.3) Calculate the mole ratio of H_2O_2 to $KMnO_4$ for each sample, and then obtain the average value:

Sample 1:

Sample 2:

Sample 3:

AVERAGE:

QUESTIONS
Experiment 4D

1. Determine the stoichiometric coefficients from the mole ratio of H_2O_2 to $KMnO_4$ for the reaction equation, and fill in the missing stoichiometric coefficients.

__ $H_2O_2(aq)$ + 2 $KMnO_4(aq)$ + 3 $H_2SO_4(aq) \rightarrow$ __ $O_2(g)$ + 2 $MnSO_4(aq)$ + $K_2SO_4(aq)$ + __ $H_2O(l)$

2. How does obtaining a dark pink endpoint (instead of a pale pink endpoint) in the titration, affect the calculated mole ratio of H_2O_2 to $KMnO_4$ compared to the actual value (what it should be)? Explain.

3. If an air bubble was unknowingly trapped in the buret tip at the beginning of the titration (but not at the end), how is the calculated mole ratio of H_2O_2 to $KMnO_4$ affected compared to the actual value (what it should be due to less to $KMnO_4$)? Explain.

Name_____ Section_____

Date_____

PRE-LAB EXERCISES
Experiment 4D

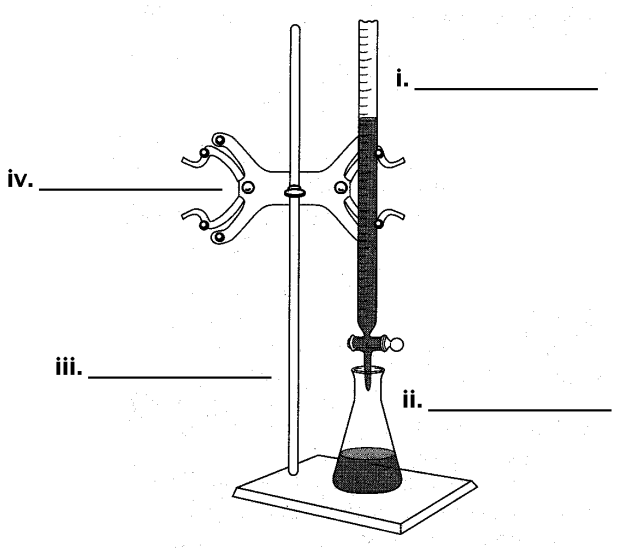
INCLUDE THE APPROPRIATE SIGNIFICANT FIGURES.

1. Correctly complete the following safety precautions when handling the H_2O_2 solution and the $KMnO_4$ solution in the laboratory?

   a. _____ solution bleaches.
   b. _____ solution stains.
   c. Apron and goggles _____ be worn.
   d. Spills _____ be cleaned up immediately.

   i. should
   ii. H_2O_2
   iii. $KMnO_4$
   iv. shall

2. The apparatus for your titration is shown in the illustration.



   a. Identify each piece of equipment.

   b. Based on the information in the Experiment Procedures, which solution(s) will you put in the glassware labeled **i**?

   c. Based on the information in the Experiment Procedures, which solution(s) will you put in the glassware labeled **ii**?

3. Calculate the mass of $NaBO_3 \cdot 4H_2O$ needed to make 250.0 mL of a 0.0300 M H_2O_2 solution. (Use three significant figures.)