Experiment 7

Percentage of Oxygen in Potassium Chlorate

INTRODUCTION:

The thermal decomposition of potassium chlorate is described by the equation

$$2\ KClO_3(s) \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$$

The purpose of this experiment is to determine the percentage of oxygen in potassium chlorate. The experimental results will be compared to the theoretical percentage calculated from the formula $KClO_3$.

While potassium chlorate decomposes simply by heating, the reaction is intolerably slow. A catalyst, manganese dioxide, MnO_2, is therefore added to speed the reaction. Although it contains oxygen, the catalyst experiences no permanent change during the reaction and does not contribute measurably to the amount of oxygen generated. As with all catalysts, the quantity present at the end of the reaction is the same as the quantity at the beginning.

The experimental procedure is to weigh a quantity of potassium chlorate, heat it to drive off the oxygen, and then weigh the residue, which is assumed to be potassium chloride. The loss in mass represents the oxygen content of the original potassium chlorate.

The "container" (see report sheet) for this experiment will be more than just the test tube, however. It will include the constant mass of catalyst that remains in the test tube throughout the experiment, plus whatever device is used to hold the test tube and its contents while they are being weighed. If the pan on the milligram balance is supported only from beneath, you can stand the test tube in a small beaker each time it is weighed, and include the beaker in the mass of the container. Be sure to use the same beaker for each weighing.

In a thermal decomposition such as this, the product must be **"heated to constant mass"** to ensure the decomposition is complete. After the first heating, cooling, and weighing of the decomposed product, the test tube must be heated, cooled, and weighed again. This process should be repeated until the weightings are the same within $\pm$ 0.005 g between two consecutive weightings.

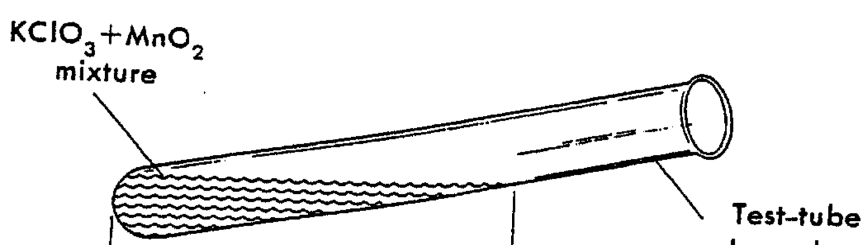

Figure 1. The proper angle for handling of the test tube while heating. Heat only in the indicated range.

SAFETY PRECAUTIONS AND DISPOSAL METHODS

This experiment is Potentially hazardous, and if performed carelessly could lead to a serious accident! The formation of a gas at the bottom of a test tube may result in a sudden expansion, blowing hot chemicals out of the test tube. This will not occur if the test tube is handled properly during heating. When heating a solid in a test tube, tip the tube until it is almost horizontal and tap it carefully until the contents are distributed over the lower half of the length of the tube, as shown in Figure 1. Holding it at about this angle, move the test tube back and forth in the flame of the burner, distributing the heat over the entire length of the mixture. **Do not concentrate the heat in any one area, particularly near the bottom of the test tube**.

Be very sure your test tube is not pointing toward anyone, including yourself, while it is being heated. Be aware of your surrounding while doing this experiment. Do not place yourself in front of somebody else's test tube. **Wearing goggles is absolutely.** Dispose of the residue in the designated waste container.

PROCEDURE

Note: Record all mass measurements to the nearest 0.01g.

A) Weigh a clean dry ignition tube and beaker. Place 0.5 to 0.8 g of manganese dioxide, MnO_2, into a large-size (Pyrex) test tube. (Do not use a *small* test tube since they are more inclined to "shoot" their contents). Measure the mass of the entire container on an analytical or centigram balance. Record the mass in the space provided on the report sheet.

B) Add about 1.0 to *1.5 g* of potassium chlorate, $KClO_3$, to the test tube. Record the mass of the container and its contents.

C) Mix the contents of the test tube until they have a somewhat uniform gray appearance. (Be careful not to lose any of the contents.) Carefully heat the test tube and its contents. Heat gently at first, increasing the intensity after the mixture seems to "boil," as it sometimes appears to do when bubbles of oxygen are being released. Continue heating for about five minutes, and then cool and weigh. Repeat the process in 5-minute heating cycles until constant mass is reached.

D) Set the container and its contents aside while you complete your calculations. Do not discard the residue until your calculations are finished and satisfactory; if they are not satisfactory, it is possible that you may be able to salvage your work if the material is still on hand.

CALCULATIONS

Using only numbers in the data portion of your report sheet, calculate by difference the initial mass of potassium chlorate and the mass of oxygen released in heating. From these quantities, find the experimental percentage of oxygen in potassium chlorate. Calculate the theoretical oxygen percentage from the formula of the compound. Using the theoretical percentage as the accepted value, calculate the percent error. It is not necessary but advisable to calculate both theoretical and experimental percent of oxygen before you continue on to the next part of the experiment.

E) In the introduction the role of the catalyst, MnO_2, was briefly discussed. A catalyst speeds up a reaction without being consumed. In other words, for the catalyst MnO_2, the mass leftover after the reaction has gone to completion should equal the mass initially measured out at the beginning of this experiment. We will test this theory. Obtain the following equipment:

Funnel	250 or 400 mL beaker	Filter paper
clamp for the funnel	wash bottle of deionized or distilled water	oven

F) Weigh a clean dry watchglass and filter paper. Record the mass on the report sheet.

G) Tighten the clamp close over the stem of the funnel so it fits securely. Position and attach the clamp to a ring stand or post so that the bottom of the funnel is inside the beaker. Flute the filter paper and use distilled water to adhere the filter paper to the funnel. Fill the ignition test tube, now containing the cooled KCl and MnO_2 mixture, with 30 to 40 mL of distilled water. Swirl. Carefully decant the saltwater solution into the filter paper. Add about 30 to 40 mL more of distilled water to the test tube still holding some of the MnO_2 then swirl. Filter this mixture but this time try to pour most of the MnO_2 into the filter paper. If some of the MnO_2 remains in the bottom of the ignition tube, simply invert the test tube over the filter paper and funnel then squirt distilled water up the tube using the wash bottle. Allow the filtrate to completely drain. Carefully remove the filter paper from the funnel, lie it on the pre-weighed watchglass, and then place it in the oven for 30 minutes to dry.

H) After 30 minutes, remove the MnO_2, filter paper, and watchglass from the oven, allow it to cool to room temperature, then re-weigh. Compare the weigh of MnO_2 before and after it was used in the reaction.

REPORT SHEET **NAME:**

Percentage of Oxygen in Potassium Chlorate

Mass of beaker and ignition test tube…………………..…..……...______________________ g
Mass of beaker and ignition tube and MnO_2 …….……..……...______________________ g
Mass of the catalyst, MnO_2… ………….……………….………..______________________ g

The container now represents the beaker, the ignition tube, and dry MnO_2
Mass of container …………………….……………………...______________________ g
Mass of container + $KClO_3$ ………….………………..……..______________________ g
Mass of $KClO_3$ …………………….………………………….______________________ g

Mass after 1st heating……..……______________________ g
Mass after 2nd heating…………______________________ g
Mass after 3rd heating…………______________________ g

Write the balanced chemical equation for the decomposition of potassium chlorate below:

Mass of container + KCl (same as mass of final heating)…..…….______________________ g
Mass of KCl produced... …………………………….…………..….______________________ g
Mass of oxygen released .…………………………….………..……______________________ g

Experimental Percent of oxygen……..…………………..………….______________________%
(Show calculations below)

Theoretical Percent of oxygen……..………………..……..……….______________________%
(Show calculations below)

Experimental error…………………..……………………..……..…….______________________%
(Show calculations below)

Mass of filter paper & watchglass…………………….……...………______________________ g
Mass of filter paper, watchglass, & MnO_2…………….……….……______________________ g
Mass of MnO_2 after being used in the reaction..…….…….….……..______________________ g

Describe your results found for the before and after weights of MnO_2. How would you explain what a catalyst is to someone who has never taken chemistry.

Problems

1. What potential hazard is present in this experiment?

2. Another thermal decomposition that produces oxygen begins with silver oxide. Assume a student collected the following data:

Mass of crucible…………………………………....30.296 g
Mass of crucible + silver oxide……………….…38.623 g
Mass of crucible + contents after
complete decomposition…………………..….38.061 g

(a) Write the balanced chemical equation for this reaction.
(b) Calculate the experimental percent of oxygen in silver oxide based on this data.
(c) Calculate the theoretical percent of oxygen in silver oxide from the formula.
(d) Calculate the percent error.

3. Sodium reacts with oxygen to form sodium oxide, Na_2O. If 7.000 g of sodium and 3.000 g of oxygen are placed in a closed container and reacted, is there sufficient sodium to react with all of the oxygen? Show evidence for your answer.