EXPERIMENT 7

Percentage of Oxygen in Potassium Chlorate

Performance Goal

7–1 Determine the percentage of one part of a compound from experimental data.

CHEMICAL OVERVIEW

The thermal decomposition of potassium chlorate is described by the equation

$$2\ KClO_3(s) \xrightarrow{\Delta} 2\ KCl(s) + 3\ O_2(g) \quad (7.1)$$

In this experiment you will determine the percentage of oxygen in potassium chlorate. You will compare your experimental result with 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 above procedure will be carried out in a test tube. The ''container'' (see page 10) 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 your milligram balance has a suspended pan and there is provision for hanging an object to be weighed, you can clamp the test tube in a test-tube holder and hang the entire assembly from the hook provided. In this case the test-tube holder is a part of the container. If the pan on your milligram balance is supported only from beneath, you can stand your test tube in a small

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beaker each time it is weighed, and include the beaker in the mass of the container. You must be sure, of course, to use the same beaker for each weighing.

In a thermal decomposition such as this, the product must be ''heated to constant mass'' before you can be sure the decomposition is complete. After the first heating, cooling, and weighing of the decomposed product, the test tube is heated, cooled, and weighed again. If the two weighings are the same, within the plus-and-minus uncertainty of the equipment used, it may be assumed that all of the oxygen was removed in the first heating. If mass is lost in the second heating, it means that some oxygen remained after the first heating and was driven off in the second. It is possible that some oxygen may still be present after the second heating, too. The procedure is therefore repeated again, as many times as necessary, until there is negligible change in mass (no more than 0.005 g for this experiment) between two consecutive weighings.

SAFETY PRECAUTIONS AND DISPOSAL METHODS

CAUTION

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 7.1. 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 anybody, including yourself, while it is being heated. Be aware of what those around you are doing while this experiment is being performed in the laboratory. Do not place yourself in the firing line of somebody else's test tube, and if another student points a test tube toward your work station, ask him or her to point it elsewhere. Obviously, *wearing goggles is absolutely mandatory while you or anyone near you is performing this experiment.*

Dispose of the residue in the designated container.

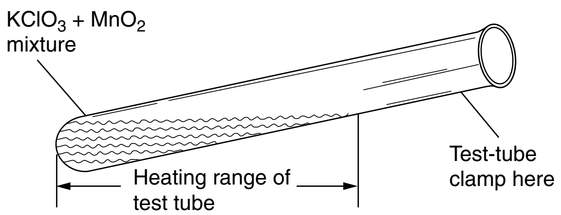

Figure 7.1

PROCEDURE

NOTE: Record all mass measurements in grams to the nearest 0.001 g.

A. Place 0.5 to 0.8 g of manganese dioxide, MnO_2, into a large-size test tube. (Do not use a *small* test tube; they are more inclined to ''shoot'' their contents.) Heat the test tube over a Bunsen burner for about 3 to 4 minutes to drive off any moisture that may be present in the catalyst and test tube. When the tube is cool to the touch, measure the mass of the entire container on a milligram balance. Record the mass in the space provided.

B. Add about 1.0 to 1.5 g of potassium chlorate, $KClO_3$, to the test tube. Find and 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 observing the procedure and safety precaution above, 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 5 minutes, and then cool and weigh. Repeat the process in 3- to 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 portions of your work page, 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 your percentage error by the equation

$$\text{Percentage error} = \frac{\text{error}}{\text{accepted value}} \times 100$$
$$= \frac{|\text{experimental value} - \text{accepted value}|}{\text{accepted value}} \times 100$$

Note that the numerator of this equation is an absolute value, simply the difference between the observed and theoretical values expressed as a positive quantity.

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Experiment 7

Advance Study Assignment

1. What potential source of laboratory accident is present in this experiment? Explain the procedure you will follow to minimize this hazard. What two precautions will you follow to prevent injury to yourself, and what will you do to avoid injuring another in the event the accident does occur?

2. Another thermal decomposition that produces oxygen begins with silver oxide: $2\ Ag_2O \longrightarrow 4\ Ag + O_2$. In a hypothetical experiment, a student collects the following data:

Mass of crucible	30.296 g
Mass of crucible + Ag_2O	38.623 g
Mass of crucible + contents after "complete" decomposition	38.061 g

Calculate the following:

a. The starting mass of Ag_2O:

b. The mass of oxygen released:

c. Experimental percentage oxygen in Ag_2O *from data:*

d. Theoretical percentage oxygen in Ag_2O *from the formula:*

e. Percentage error:

Name ______ Date ______ Section ______

Experiment 7

Work Page

Constant Mass Data

Trial	*1*	*2*	*3*	*4*
1st heating (g)				
2nd heating (g)				
3rd heating (g)				
4th heating (g)				
Final heating (g)				

Mass Data

Mass of container (g)				
Mass of container + $KClO_3$ (g)				
Mass of container + KCl (g)				

Results

(Show all calculations for one column on the next page)

Mass of $KClO_3$ used (g)				
Mass of oxygen released (g)				
Percentage oxygen				
Percentage error				

Complete Calculations from One Column of Table:

Calculation of Percent Oxygen in $KClO_3$ from Formula:

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Experiment 7

Report Sheet

Constant Mass Data

Trial	*1*	*2*	*3*	*4*
1st heating (g)				
2nd heating (g)				
3rd heating (g)				
4th heating (g)				
Final heating (g)				

Mass Data

Mass of container (g)				
Mass of container + $KClO_3$ (g)				
Mass of container + KCl (g)				

Results

(Show all calculations for one column on the next page)

Mass of $KClO_3$ used (g)				
Mass of oxygen released (g)				
Percentage of oxygen				
Percentage error				

Complete Calculations from One Column of Table:

Calculation of Percent Oxygen in $KClO_3$ from Formula: