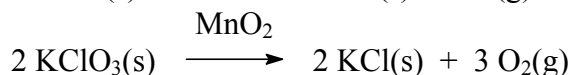
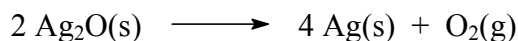


The Decomposition of Potassium Chlorate

Small quantities of molecular oxygen (O₂) can be obtained from the thermal decomposition of certain oxides, peroxides, and salts of oxoacids. Some examples of these reactions are



The last reaction, the decomposition of potassium chlorate, includes manganese(IV) oxide (MnO₂) as a catalyst. A **catalyst** is a substance that causes an increase in the rate of a chemical reaction without being used up in the reaction. It is this reaction that will be studied in this experiment.

The thermal decomposition of KClO₃ (potassium chlorate) in the **absence** of a catalyst will be studied. The identity of the solid that remains after the decomposition can be determined from the quantity of oxygen that is evolved. Identification can then be made by comparing the measured mass of the solid product with a calculated value based on the quantity of O₂.

The solid product that results from the thermal decomposition of KClO₃ is KCl when the catalyst MnO₂ is present. What will happen if the catalyst is not added? Will the loss of oxygen be less extensive? If so, the solid product could be either KClO₂ (potassium chlorite) or KClO (potassium hypochlorite). This experiment will investigate these questions. The three reactions that could possibly occur can be written and balanced based on these predictions.

A sample of KClO₃ of known mass will be heated in the absence of a catalyst until the evolution of oxygen is complete. Oxygen will be collected in a flask by the displacement of water. The volume of water displaced equals the volume of O₂ gas produced. In order to determine the correct stoichiometry of this reaction, **you will need to obtain the number of moles of O₂ that have been evolved**. You can calculate this quantity from the rearranged form of the ideal gas law:

$$n = \frac{PV}{RT}$$

where **P** refers to the **partial pressure of oxygen** in the collected gas mixture, **V** is the volume of water displaced, **T** is the Kelvin temperature of the gas mixture, and **R** is the constant. A commonly used value for R is 0.082056 L·atm/mol·K. If this value for **R** is used, then **P** must be expressed in atmospheres and **V** in liters.

Since the oxygen is collected over water, water vapor will also be present in the gas. The experiment is designed so that the total pressure of the oxygen and water vapor will be equal to the atmospheric pressure:

$$P_{\text{Total}} = P_{\text{O}_2} + P_{\text{H}_2\text{O}}$$

you can easily measure atmospheric pressure with a barometer. **The partial pressure of oxygen in the flask can be calculated by subtracting the vapor pressure of water from the atmospheric pressure.** Table I gives the vapor pressure of water at various temperatures.

Figure I shows the apparatus for this experiment. The sample of KClO_3 is placed in the test tube and the Erlenmeyer flask is filled with water. Some of the water is displaced by oxygen and is pushed into the beaker. The volume of water in the beaker will be identical to the volume of oxygen in the flask.

Procedure

1. Record the atmospheric pressure from the laboratory barometer. This will equal the pressure of the ($\text{O}_2 + \text{H}_2\text{O}$) gas mixture that develops in your Erlenmeyer flask.
2. **Caution: KClO_3 is a very strong oxidizing agent. Make certain you place the lid back on the bottle containing the KClO_3 after you obtain your sample. Do not let this substance contact paper or the rubber stopper in the test tube of the apparatus.**
3. Record the weight of the beaker on a top-loading balance. Assemble the apparatus as shown in Figure I.
4. Fill the Erlenmeyer flask with distilled water, so that the level of the water is about 1 inch below the short glass tube. Open the pinch clamp. Remove the stopper from the test tube. Use a suction bulb to force air through the glass tube (test-tube end) until the rubber tube is filled with water. Allow a little water to enter the beaker to about 2 inches. Close the pinch clamp near the end of the tubing where the water will exit.
5. Make sure that the test tube is clean and dry. Take the test tube and a clean, empty, dry 400 mL beaker to the top-loading balances. Tare the empty beaker, add the test-tube and record its mass. Tare the beaker and test-tube.
6. Carefully add a small amount of KClO_3 to the test tube. Continue to add KClO_3 until you have about 1.0 g of KClO_3 in the test tube. A sample in the range of 0.9 g to 1.1 g of KClO_3 will work. Record the mass to 0.01 g.
7. Clamp the test-tube to the ringstand and stopper the test tube.
8. Open the pinch clamp. Lift the beaker with your hands until the water level in the beaker is equal to the water level in the Erlenmeyer flask. When the water levels are equal, have your partner close the pinch clamp. This equalizing process will ensure that the pressure acting on the water in the beaker (atmosphere) is equal to the pressure acting on the water in the flask.

9. Empty the beaker but do not dry it. The volume of the water drops that remain in the beaker will be roughly equal to the volume that will remain after the displaced water is poured into a graduated cylinder for measurement.
10. Place the glass tube (connected to the hose) back into the beaker. **MAKE CERTAIN THE PINCH CLAMP IS OPEN!**

Caution: If the clamp is not opened at this point, the build-up of gas during heating could cause an explosion, although it is more likely that a stopper would be forced to loosen. Also, make certain that the longer glass rod is not touching the bottom of the Erlenmeyer flask. This would also result in a closed system and an explosion could result.

11. Heat the test tube. The solid will melt, oxygen will be evolved, and water from the flask will be displaced into the beaker. Be cautious at first and brush the flame over the test tube. After a few minutes when the liquid solidifies, the test tube can be heated more strongly. One gram of KClO_3 reactant should cause the displacement of between 250 and 300 mL of water.
12. Heat the solid thoroughly until no more gas is evolved. The contents of the test tube will solidify, since the melting point of the product is greater than that of KClO_3 .
13. Turn off the flame and allow the system to come back to room temperature. Allow five minutes for this process.
14. As in step 8, equalize the water levels (this may require lifting the Erlenmeyer flask) and close the clamp.
15. Remove the tube from the beaker. Record the mass of the beaker plus the water on a top-loading balance. Use Table I to determine the **volume** of water displaced.
16. Measure the temperature of the water to the nearest degree. Assume this is the temperature of the gas. Determine the appropriate vapor pressure of water from Table II.
17. Obtain the mass of the test-tube and its contents. Calculate and record the mass of the product.
18. If you have any reason to believe that your experiment did not work (e.g. you did not get ca. 300 mL of water transfer during the experiment), repeat steps 6-24 with a second sample of KClO_3 . If you believe that you were able to capture the complete volume of oxygen gas, a second trial is not necessary.

Figure I: A diagram of the laboratory setup used in this experiment.

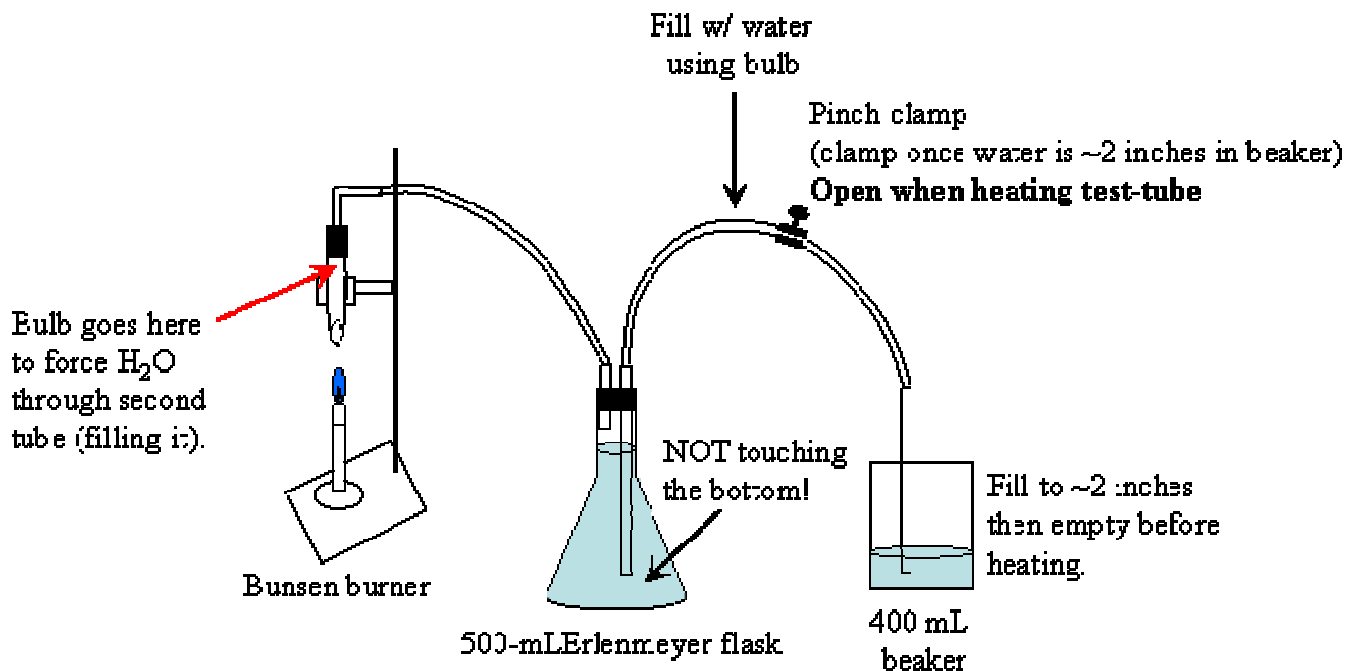


Table I Density (g/mL) of Water at Various Temperatures (° C)

Temp.	Density	Temp.	Density	Temp.	Density
17	0.9988	22	0.9978	27	0.9965
18	0.9986	23	0.9976	28	0.9962
19	0.9984	24	0.9973	29	0.9959
20	0.9982	25	0.9971	30	0.9956
21	0.9980	26	0.9968	31	0.9953

Table II Vapor Pressure of Water (torr) (data from the CRC Handbook of Chemistry and Physics, 49th edition, 1968.)

Temp.	Vapor Pressure	Temp.	Vapor Pressure	Temp.	Vapor Pressure
17	14.5	22	19.8	27	26.7
18	15.5	23	21.1	28	28.3
19	16.5	24	22.4	29	30.0
20	17.5	25	23.8	30	31.8
21	18.7	26	25.2	31	33.7

Questions

1. Write a **balanced** chemical equation for each of the three possible reactions that could occur when **potassium chlorate**, KClO_3 is thermally decomposed.
2. Suppose the atmospheric pressure when you performed your experiment was 751 torr. The temperature of your water was found to be 23.0°C . What is the pressure of the oxygen gas, P_{O_2} , that is produced?

Data Treatment

1. Determine:
 - a. moles of oxygen that were produced.
 - b. moles KClO_3 that were reacted.
 - c. ratio of the number of moles of oxygen to the number of moles of KClO_3 .

Write the chemical equation for the reaction that the data suggest occurred.

2. Using the mass of reactant KClO_3 that you used in your most successful trial, calculate how many grams of each of the solid products of each possible reaction would theoretically be produced in the decomposition. Which decomposition reaction occurred, **based on the mass of solid generated in the reaction**? Write the chemical equation for the reaction that the data suggest occurred:
3. You determined which chemical reaction occurred by analyzing the amount of gas produced in the reaction, and the mass of solid product remaining after reaction. Which determination method do you believe is more reliable, the analysis of the mass of the solid product or the analysis of the gas produced? Explain your answer.
4. In the presence of a catalyst, KCl is produced in the thermal decomposition of KClO_3 . You did not use a catalyst. Did you get the same products for this reaction as you would have with a catalyst?