Principles and Concepts

The object of this experiment is to test an experimental law, the Law of Constant Composition. The behavior of matter which this law describes is one of the properties which John Dalton sought to explain by his Atomic Theory. The law may be stated as follows: **When two or more elements combine to form a compound they always do so in a fixed, or definite, proportion by weight.**

For this experiment adopt as your hypothesis that the Law of Constant Composition holds for the combination of magnesium and oxygen and for the decomposition of potassium chlorate. There are then two distinct reactions we will do in this lab.

**Formation of MgO**

You will weigh some magnesium (two ~ 1 inch strips), combine them with oxygen (oxidize it), and weigh the product. From these weights you can calculate the proportion in which magnesium and oxygen combine. Then by tabulating results obtained by each member of the class, we may test your hypothesis; if these results agree, within the limits of the experiment, the hypothesis passes the test; if they do not agree within these limits, then you must re-examine your hypothesis, or the data, or both. One of your jobs in evaluating the evidence, then, will be to determine the limits of accuracy of the experimental procedure.

**Experimental Procedure:**

There are 5 steps involved in oxidizing the Mg (magnesium) to MgO (magnesium oxide):

1. In a preliminary step, clean, heat and cool an empty crucible and cover.
2. Weigh the crucible and cover.
3. Add a sample of magnesium ribbon and weigh it again.
4. Oxidize the sample in the crucible over a bunsen burner.
5. Weigh the cooled crucible, cover, and MgO.

These steps are described more fully on the following procedures.

**Step 1:** Clean a crucible and cover and then support it with a clay triangle on a ring stand as shown in the following diagram:

Heat the covered crucible in the full heat of the burner until the bottom glows red for a couple of minutes.

**Step 2:** When the crucible and lid have cooled, weigh them together and record the mass to the nearest 0.0001 g in the data table on page 3.
Step 3: Coils to fit in the bottom of the crucible and add about ~ 0.09 g of polished magnesium ribbon to the crucible. Weigh the crucible and cover with the sample in it, again to the nearest 0.0001 g, and record the mass.

Step 4: To oxidize the magnesium, heat the crucible on the clay triangle with the lid vented slightly to allow access to the air. Caution must be used at this point to keep from losing magnesium oxide as "smoke." You can control the rate of the oxidation reaction (ignition) in two ways: 1) by decreasing or increasing the heat on the crucible, and 2) by controlling the supply of oxygen (air) by opening or closing the crucible cover. This is conveniently handled with your crucible tongs. By taking advantage of these two controls, allow the reaction to proceed as rapidly as possible without excessive smoking. While some smoke is unavoidable, try to keep it to a minimum; this will mean keeping the reaction quite slow at first. (Patience is a necessary attribute of the successful laboratory worker.)

As the oxidation is nearing completion, the crucible contents will no longer glow brightly when the cover is lifted. At this point move the cover to one side and apply the full heat of the burner for another five minutes.

Step 5: Cover the crucible and allow to cool to room temperature. Again weigh it to the nearest 0.0001 g and record the mass.

Trial #2 is done by repeating steps 1 through 5.

From your experimental data calculate the weight of your sample of Mg, the weight of the MgO formed when it combined with oxygen and the percentage of Mg in MgO. Remember that percentage means "parts per hundred."

Decomposition of KClO₃
The thermal decomposition of potassium chlorate introduces the elimination of oxygen from a compound by heating. KClO₃ decomposes according to the equation:

$$\text{2KClO}_3 \rightarrow \text{2KCl} + 3\text{O}_2$$

This process requires heat and to get the job done in reasonable time requires a catalyst. STOP RIGHT NOW AND LOOK UP THE MEANING OF THE WORD, "CATALYST". Once the oxygen is driven off, we can use the numerical results to back track to the salt oxygen ratio as before. We can also compare the % oxygen with a theoretical % and obtain a percent error.

Method (Repeat this experiment at least two times.)

There are 5 steps involved in decomposing the KClO₃ into KCl and O₂:
1. In a preliminary step, clean, and dry an empty crucible and cover.
2. Add prescribed amount of Fe₂O₃, heat, cool then weigh the crucible/cover/Fe₂O₃.
3. Add a sample of potassium chlorate and weigh it again.
4. Decompose the sample in the crucible over a bunsen burner.
5. Weigh the cooled crucible, cover, and remaining KCl.

These steps are described more fully on the following procedures.
Step 1: Clean a crucible and cover and then support it with a clay triangle on a ring stand as shown in the following diagram:

Heat the covered crucible in the full heat of the burner until the bottom glows red for a couple of minutes.

Step 2: a) Place a small amount of Fe$_2$O$_3$ catalyst in a clean dry crucible--cover the crucible with a lid and heat the combination strongly in a Bunsen flame for about 2 minutes. This removes any moisture from the Fe$_2$O$_3$ and crucible.

b) Allow the crucible and Fe$_2$O$_3$ to cool until you can handle it comfortably record the mass of crucible, lid and contents to the nearest 0.0001 g in the data table on page

   c) Place about 1.5 grams of KClO$_3$ in the crucible and record the mass of crucible, lid and contents to the nearest 0.0001 g in the data table on page 1 of the data sheet.

Step 4: Heat the crucible, lid and contents in a strong Bunsen flame for about 5 minutes.

Step 5: Allow to cool and record the mass of crucible, lid and contents to the nearest 0.0001 g in the data table on page 1 of the data sheet. (Note: The loss in weight represents the oxygen gas which has been driven off. Since this system will occasionally deliver a little chlorine gas to the surroundings, we will not reheat the crucible if the results are fairly close.)

From your experimental data calculate the weight of your sample of KClO$_3$, the weight of the KCl remaining when it decomposed and the percentage of O$_2$ in KClO$_3$. Remember that percentage means "parts per hundred."
Form 161 The Law of Constant Composition

Name ________________________________ Partner name ____________________

Trial

Formation of MgO

Data:

1. Mass of crucible and cover after preliminary heating

2. Mass of crucible, cover, and Mg before ignition

3. Mass of crucible, cover, and MgO after ignition

Calculations:

4. Mass of magnesium taken (Entry 2 - Entry 1)

5. Mass of magnesium oxide obtained (Entry 3 - Entry 1)

6. Percentage of Mg in MgO (Entry 4 divided by Entry 5) x 100

7. Class Average (to be filled as available)

Decomposition of KClO₃

Data:

1. Mass of crucible and cover after preliminary heating

2. Mass of crucible, cover, and Fe₂O₃ after heating

3. Mass of crucible, cover, Fe₂O₃, and KClO₃ before decomposition

4. Mass of crucible, cover, Fe₂O₃, and KCl after decomposition

Calculations:

5. Mass of KClO₃ taken (Entry 3 - Entry 2)

6. Mass of O₂ released (Entry 3 - Entry 4) / 

7. Percentage of O₂ in KClO₃ (Entry 6 divided by Entry 5) x 100

8. Class Average (to be filled as available)

Additional calculations/Questions

1. Calculate the expected weight % of Mg in MgO and the expected weight % of oxygen in KClO₃

Show calculations

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2. Calculate the moles of Mg used, moles of O absorbed and then the molar ratio. What is the expected molar ratio between Mg and O in MgO? Show calculations.

\[
\text{Moles Mg} \quad \text{Moles O} \quad \text{Molar ratio} \quad \text{Expected ratio}
\]

3. Calculate the moles of KClO\textsubscript{3} used, moles of O\textsubscript{2} released and then the molar ratio. What is the expected molar ratio between KClO\textsubscript{3} and O\textsubscript{2} in KClO\textsubscript{3}? Show calculations.

\[
\text{Moles KClO}_3 \quad \text{Moles O}_2 \quad \text{Molar ratio} \quad \text{Expected ratio}
\]

4. Examine the results obtained by the whole class when these have been tabulated and your molar ratio results. Within reasonable limits of experimental error, do these results support our original hypothesis, i.e., when two or more elements combine to form a compound they do so in a fixed, or definite, proportion by weight? Explain the basis for your opinion.

5. Think back over your technique in these experiment and list some of the probable errors that may cause results to deviate from the Law of Constant Composition.

1. __________________________________________________________
2. __________________________________________________________
3. __________________________________________________________

6. How might you redesign the first experiment to take into account the loss of MgO as smoke?