

# PERCENT COMPOSITION

## EXPERIMENT 6

### OBJECTIVE

The objective of this experiment is to determine the percent composition of potassium chloride and oxygen in a sample of potassium chlorate and to compare the experimental results with the theoretical values.

### EQUIPMENT AND CHEMICALS

Potassium chlorate (anhydrous  $\text{KClO}_3$ )  
Ring stand with clay triangle  
Bunsen burner  
Triple beam balance

### DISCUSSION

The percent composition of a compound is the relative amount of mass contributed by each element in the compound based on 100. An example, which is similar to the percent composition of a compound, is the percent composition of the students in the class. Let us say that there are 20 students in the class. In this class, there are four types of students.

Texans	=	10 students
Okies	=	6 students
Yankee	=	3 students
Others	=	1 student

What we want to know is "What is the percent composition of each type of student in the class?"

To find the percent composition, we divide the number of each student type by the total of all the students and multiply by 100.

$$\% \text{ composition} = \frac{\text{part contributed by the component}}{\text{whole}} \times 100$$

From the data given, we can calculate the percent composition of the class.

$$\% \text{Texans} = \frac{\text{number of Texans}}{\text{total class}} \times 100 = \frac{10}{20} \times 100 = 50\%$$

$$\% \text{ Okies} = \frac{\text{number of Okies}}{\text{total class}} \times 100 = \frac{6}{20} \times 100 = 30\%$$

$$\% \text{ Yankees} = \frac{\text{number of Yankees}}{\text{total class}} \times 100 = \frac{3}{20} \times 100 = 15\%$$

$$\% \text{ Others} = \frac{\text{number of Others}}{\text{total class}} \times 100 = \frac{1}{20} \times 100 = 5\%$$

The sum of percentages should equal 100%.

Texans	=	50%
Okies	=	30%
Yankees	=	15%
<u>Others</u>	=	<u>5%</u>
Total	=	100%

The percent composition of a compound is determined the same way. Instead of using students, we use the various elements. Each element has its own particular mass (atomic mass). This atomic mass is multiplied by the number of atoms of the particular elements in the compound.

**Example 1:** The atomic mass of oxygen = 16 amu. If there are three atoms of oxygen, the total mass of all the oxygen atoms = 3 X 16 amu = 48 amu.

Each element in the compound is determined in the above manner. The individual mass of each element is then added together to get the total mass (formula mass) of the compound.

The percent composition of the compound can then be determined by dividing the part (the formula mass contributed by each element) by the whole (the formula mass of the compound) and multiplying by 100.

**Example 2:** Calculate the atomic mass of Na<sub>2</sub>SO<sub>4</sub>

Step 1 - There are two atoms of sodium, one atom of sulfur, and four atoms of oxygen.

Step 2 - Write the atomic mass of each element:

Atomic weight of Na = 23.0 amu

Atomic weight of S = 32.1 amu

Atomic weight of O = 16.0 amu

Step 3 - Calculate the formula weight contributed by each element:

Na = 2 atoms x 23.0 = 46.0 amu

S = 1 atom x 32.1 = 32.1 amu

O = 4 atoms x 16.0 = 64.0 amu

Step 4 - The total weight of  $\text{Na}_2\text{SO}_4$  is the sum of all the weights of all the elements.

$$\begin{array}{rcl} \text{Na} & = & 46.0 \text{ amu} \\ \text{S} & = & 32.1 \text{ amu} \\ \underline{\text{O}} & = & \underline{64.1 \text{ amu}} \\ \text{Na}_2\text{SO}_4 & = & 142.1 \text{ amu} \end{array}$$

**Example 3:** Calculate the % composition of  $\text{Na}_2\text{SO}_4$   
The formula weight of  $\text{Na}_2\text{SO}_4 = 142.1 \text{ amu}$

$$\% \text{Na} = \frac{46}{142.1} \times 100 = 32.4 \%$$

$$\% \text{S} = \frac{32.1}{142.1} \times 100 = 22.6 \%$$

$$\% \text{O} = \frac{64.1}{142.1} \times 100 = 45.0 \%$$

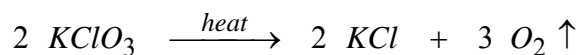
The total of all the percentages should equal 100%.

**Example 4:**

$$\begin{array}{rcl} \% \text{Na} & = & 32.4\% \\ \% \text{S} & = & 22.6\% \\ \underline{\% \text{O}} & = & \underline{45.0\%} \\ \text{Total} & = & 100.0\% \end{array}$$

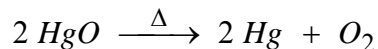
When the percent composition is calculated using the formula of a compound and the atomic weights, it is called the theoretical percent composition. In this experiment we will determine the theoretical percent composition of potassium chloride (KCl) and oxygen (O) in a sample of potassium chlorate ( $\text{KClO}_3$ ). We will, also, experimentally determine these percentages.

When potassium chlorate is heated, it evolves oxygen as a gas.



The initial weight of the  $\text{KClO}_3$  is determined, the sample is heated to evolve the oxygen, and the remaining KCl is weighed.

**Example 5:** What is the experimental percent composition of HgO when heated in a crucible?



## B. Experimental Weighing

$$\begin{aligned} \text{mass of crucible} &= 15 \text{ g} \\ \text{mass of crucible} + \text{HgO} &= 115 \text{ g} \\ \text{mass of crucible and residue} &= 106.5 \text{ g} \end{aligned}$$

## B. Calculation of mass

- $\text{mass of HgO} = (\text{mass of crucible} + \text{HgO}) - (\text{mass of crucible})$   
 $\text{mass of HgO} = (115 \text{ g} - 15 \text{ g}) = 100 \text{ g}$
- $\text{mass of residue (Hg)} = (\text{mass of crucible after heating}) - (\text{mass of crucible})$   
 $\text{mass of residue (Hg)} = (106.5 \text{ g}) - (15 \text{ g}) = 91.5 \text{ g}$
- $\text{mass of loss (oxygen)} = (\text{mass of HgO}) - (\text{mass of residue})$   
 $\text{mass of loss (oxygen)} = (100 \text{ g}) - (91.5 \text{ g}) = 8.5 \text{ g}$

## C. Calculation of percent composition

$$\% \text{ Hg} = \frac{\text{mass of residue}}{\text{total mass}} = \frac{91.5 \text{ g}}{100 \text{ g}} \times 100 = 91.5 \%$$

$$\% \text{ O} = \frac{\text{mass of loss}}{\text{total mass}} = \frac{8.5 \text{ g}}{100 \text{ g}} \times 100 = 8.5 \%$$

We can compare the experimental result with the calculated theoretical result to determine how accurate our results were.

$$\text{percent error} = \frac{(\text{experimental value} - \text{theoretical value})}{\text{theoretical value}} \times 100$$

We still must calculate the theoretical composition of HgO. The formula mass of HgO = 216.6 amu. The atomic mass of Hg = 200.6 amu and that of oxygen = 16 amu. The percent composition of Hg = 92.6% ( $200.6 \times 100/216.6$ ) and percent oxygen = 7.4% ( $16 \times 100/216.6$ ).

**Example 6:** Calculate the percent error in the determination of Hg and oxygen.

$$\text{percent error} = \frac{(\text{experimental value} - \text{theoretical value})}{\text{theoretical value}} \times 100$$

$$\text{percent error Hg} = \frac{(91.5\% - 92.6\%)}{92.6\%} \times 100 = -1.2\%$$

$$\text{percent error Hg} = \frac{(8.5\% - 7.45\%)}{7.45\%} \times 100 = 14.9\%$$

## PROCEDURE

### PART A DETERMINATION OF MASS

Potassium chlorate ( $\text{KClO}_3$ ) will be heated to evolve oxygen. The difference in weight will be due to the evolution of oxygen. Using the experimentally determined weights, the percent composition of  $\text{KClO}_3$  can be determined.

DO TWO SAMPLES AT THE SAME TIME.

1. Heat a clean 25 ml crucible and lid for approximately five minutes to remove any combustible material.
  2. Weigh the cool crucible and lid and record the mass of the crucible. NOTE: all masses should be read to the nearest 0.1 grams.
  3. Add approximately three grams of reagent grade  $\text{KClO}_3$  to the crucible. Record the mass of the crucible, lid, and  $\text{KClO}_3$ .
  4. Heat the crucible gently for about five minutes.
  5. Increase the heat so that the bottom of the crucible becomes a dull red. Heat for 15 minutes.
  6. Allow the crucible to cool to room temperature. This is the temperature at which you can comfortably pick up the crucible. Do not place the hot crucible on the tabletop. Use a piece of wire screen to rest the crucible on.
  7. Weigh the crucible and lid and record the mass.
- NOTE: Any future references to the crucible include the lid.**



8. Reheat the crucible to a dull red glow for five minutes more.
9. Cool and weigh the crucible. Record this mass under the 2nd heating.
10. If the two masses are not within 0.1 grams of each other, reheat for an additional five minutes and re-weigh.

$$\text{mass of KClO}_3 = (\text{mass of crucible} + \text{KClO}_3) - (\text{mass of crucible})$$

$$\text{mass of KCl} = (\text{mass of crucible after heating}) - (\text{mass of crucible})$$

$$\text{mass of loss (oxygen)} = (\text{mass of KClO}_3 - (\text{mass of crucible after heating}))$$

**PART B: DETERMINATION OF PERCENT POTASSIUM CHLORIDE AND OXYGEN FROM EXPERIMENTAL RESULTS**

1. Calculate the % KCl in the sample of KClO<sub>3</sub>.
2. Calculate the % oxygen in the KClO<sub>3</sub>.

**PART C: DETERMINATION OF THE THEORETICAL PERCENT COMPOSITION OF % POTASSIUM CHLORIDE AND OXYGEN IN POTASSIUM CHLORATE**

1. Calculate the formula mass of KClO<sub>3</sub>, KCl, and the oxygen atoms.
2. Calculate the theoretical composition of KCl in KClO<sub>3</sub>.
3. Calculate the theoretical composition of oxygen in KClO<sub>3</sub>.

**PART D: DETERMINATION OF ERROR BETWEEN THE THEORETICAL VALUE AND THE EXPERIMENTAL VALUE**

1. Determine the percent error in the KCl determination.
2. Determine the percent error in the oxygen determination.

NAME \_\_\_\_\_  
DATE \_\_\_\_\_  
SECTION \_\_\_\_\_

**PERCENT COMPOSITION OF POTASSIUM CHLORATE  
REPORT SHEET  
EXPERIMENT 6**

**DETERMINATION OF MASSES**

	<b>Sample 1</b>	<b>Sample 2</b>
1. Mass of crucible	_____	_____
2. Mass of crucible and $\text{KClO}_3$	_____	_____
3. Mass of crucible and $\text{KCl}$ (1st heating)	_____	_____
4. Mass of crucible and $\text{KCl}$ 2nd heating)	_____	_____
5. Mass of crucible and $\text{KCl}$ (3rd heating, if needed)	_____	_____

Calculate the weight of  $\text{KClO}_3$  (total weight)

Grams  $\text{KClO}_3$  \_\_\_\_\_

Calculate the weight of  $\text{KCl}$  remaining in the crucible (residue)

Grams  $\text{KCl}$  \_\_\_\_\_

Calculate the weight of oxygen given off (loss)

Grams Oxygen \_\_\_\_\_

**DETERMINATION OF PERCENT KCl AND OXYGEN FROM EXPERIMENTAL RESULTS**

- |   | <b>Sample 1</b> | <b>Sample 2</b> |
|---|-----------------|-----------------|
| 1. Calculate the % KCl in $KClO_3$                    |                 |                 |
| % KCl =   | _____           | _____           |
| 2. Calculate the % oxygen in $KClO_3$                 |                 |                 |
| % Oxygen =  | _____           | _____           |
| 3. Does the sum of the % KCl and % oxygen equal 100%? |                 |                 |

**DETERMINATION OF THE THEORETICAL PERCENT COMPOSITION OF % POTASSIUM CHLORIDE AND % OXYGEN IN POTASSIUM CHLORATE**

1. The formula mass of potassium chloride = \_\_\_\_\_ amu
  2. The atomic mass of oxygen x the number of oxygens in  $KClO_3$  = \_\_\_\_\_ amu
  3. Calculate the formula mass of  $KClO_3$
- Formula mass  $KClO_3$  = \_\_\_\_\_
4. Calculate the theoretical % composition of KCl in  $KClO_3$ .
- % KCl = \_\_\_\_\_
5. Calculate the theoretical % composition of oxygen in  $KClO_3$ .
- % Oxygen = \_\_\_\_\_
6. Does the sum of % KCl and % Oxygen equal 100%?

**DETERMINATION OF EXPERIMENTAL ERROR**

	<b>Sample 1</b>	<b>Sample 2</b>
1. Calculate the % error KCl determination.	_____	_____
2. Calculate the % error in the oxygen determination.	_____	_____
3. What does the % error indicate about your experimental technique?		