Lab Session 5, Experiment 4: Law of Definite Proportions

The law of definite proportions states that when two or more elements combine to form a given compound, they do so in fixed proportions by mass. This is the same as saying the composition of a compound is fixed. For example, sodium chloride contains 39.3% by mass sodium and 60.7% by mass chlorine.

In this experiment a sample of $KClO_3$ will be decomposed thermally, and the oxygen produced will be expressed as a percentage of the original mass of $KClO_3$. Experimental results will then be compared to the theoretical percentage of oxygen in $KClO_3$.

4A Experiment: Decomposition of a Salt

1. Add approximately 0.1 g of MnO_2 to a clean, dry crucible and weigh the crucible including the catalyst. Enter the mass on line (b) below.
2. Add $KClO_3$ to the crucible until it is about one-third full. Mix the $KClO_3$ and MnO_2 thoroughly. Weigh again and enter the mass on line (a) below.
3. Place the crucible on a wire triangle supported on a ring clamp. Adjust the ring clamp to a height that allows the crucible to be heated with the flame of your burner.
4. Heat the crucible slowly at first. Then regulate heating to prevent boil-over from the crucible. The objective is to completely decompose the chlorate to the chloride and oxygen; therefore, heat for about ten minutes after apparent total decomposition. Heating should be so vigorous as to cause the bottom of the crucible to glow red. Heat until all purple color is

Hydrates

Hydrates are substances formed when water combines chemically in definite proportions with a salt. The ratio of water molecules to the ions of the salt is a constant. Hydrates are not mixtures. The anhydrous (without water) form of the salt is produced when all the water of hydration is lost. Some examples of hydrates are listed below:

Formula	Names
$(CaSO_4)_2 \cdot H_2O$	calcium sulfate hemihydrate "plaster of paris"
$CaSO_4 \cdot 2H_2O$	calcium sulfate dihydrate "gypsum"
$CuSO_4 \cdot 5H_2O$	copper (II) sulfate pentahydrate "blue vitriol"
$MgSO_4 \cdot 7H_2O$	magnesium sulfate heptahydrate "epsom salt"
$Na_2CO_3 \cdot 10H_2O$	sodium carbonate decahydrate "washing soda"

The • in the formula indicates a kind of chemical bond that usually can be easily broken. For example, copper (II) sulfate pentahydrate can be converted to anhydrous copper (II) sulfate by heating:

$$CuSO_4 \cdot 5H_2O_{\ (sol)} \rightarrow CuSO_{4\ (sol)} + 5H_2O_{\ (gas)}.$$

In $CuSO_4 \cdot 5H_2O$ the bonding involves four water molecules coordinatively bound to the Cu^{2+} ion in a square planar structure (Figure 5.1) and one molecule of water bound to the sulfate ion by hydrogen bonds (Figure 5.2).

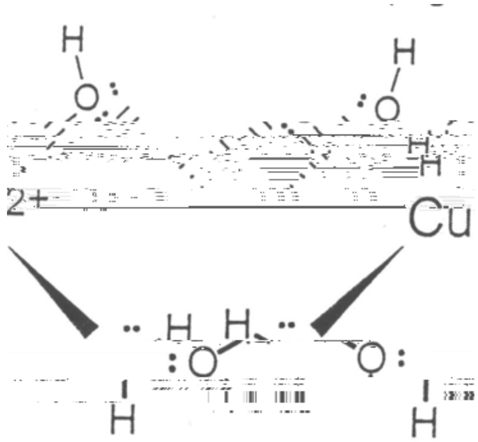

Figure 5.1

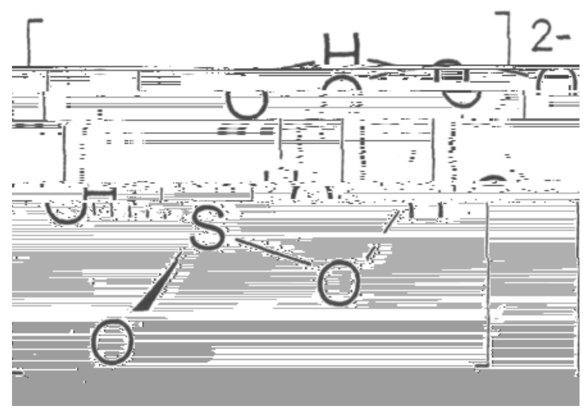

Figure 5.2

Loss of hydration water to the atmosphere is called **efflorescence**. The property of some salts to collect moisture from the air and dissolve in it is called **deliquescence**. A compound is **hygroscopic** if absorption of water from the atmosphere occurs without dissolution of the compound.

4B Experiment: Composition of a Hydrate

In the following experiment, record all masses in the data table.

1. Weigh your evaporating dish.
2. Introduce about 5 g of pulverized hydrated $CuSO_4$. Note the appearance and color of the solid; weigh the dish and contents.
3. Place the evaporating dish on the wire gauze and heat slowly until the color disappears. Prolonged heating may result in the decomposition of the anhydride. What color change occurred?____
4. When cool, weigh the dish and anhydride.
5. From the data, calculate the following:

4C Experiment: Properties of hydrates

1. Place crystals of calcium chloride, washing soda, and lithium chloride on a watch glass and expose them to the air of the laboratory.
2. Note the appearance of each sample towards the end of the lab. Which crystals deliquesce?

____

Which crystals effloresce?

____

Explain why one sample gained water and why one lost water.

____

4D Experiment

1. Introduce one spatula of each of the following into separate test tubes: sodium chloride, potassium dichromate, aluminum sulfate, cobalt chloride, and nickel sulfate. Record color before heating in the table below.
2. Heat each sample in turn, holding the tube at an angle of about 30^{o} so that any water will condense in the cool part of the tube. Record color after heading in the table below.
3. When you heated salts in this experiment, which ones lost water?

   ____

4. Can the original color be restored by addition of a few drops of water to the cooled tube?

   ____

   List any hydrates that changed color upon heating, but for which the color came back when water was added.

   ____

	Color Before Heating	**Color After Heating**
(a) Sodium Chloride		
(b) Potassium Dichromate		
(c) Aluminum Sulfate		
(d) Cobalt Chloride		
(e) Nickel Sulfate		

Report Form 4: Law of Definite Proportions

Name____________________________________

Partner____________________Section #_____

4A Experiment: Decomposition of a Salt

(a) Mass of crucible with MnO_2 and $KClO_3$	g
(b) Mass of crucible with MnO_2	g
(c) Mass of $KClO_3$ [(a)–(b)]	g
(d) Mass crucible and contents after heating	g
(e) Mass of oxygen [(a)–(d)]	g
(f) Mass of KCl [(c)–(e)]	g
(g) Experimental percentage of oxygen	%
(h) Theoretical percentage of oxygen	%
(i) Percent error in experimental percentage of oxygen	%
(j) Experimental moles of O	mol
(k) Experimental moles of KCl	mol
(l) Calculated value of above ratio	
(m) Formula of compound decomposed	

4C Experiment: Properties of hydrates

Which crystals deliquesce?____

Which crystals effloresce?____

Explain why one sample gained water and why one lost water.____________________

4D Experiment

When you heated salts in this experiment, which ones lost water?

Can the original color be restored by addition of a few drops of water to the cooled tube?

List any hydrates that changed color upon heating, but for which the color came back when water was added.____

	Color Before Heating	Color After Heating
(a) Sodium Chloride		
(b) Potassium Dichromate		
(c) Aluminum Sulfate		
(d) Cobalt Chloride		
(e) Nickel Sulfate		