Determination of a chemical formula

CHEM 1105 Experiment 4: Determination of a Chemical Formula Introduction When atoms of one element combine with those of another, the combining ratio is typically an integer or a simple fraction. The simplest formula of a compound expresses that atom ratio. When two or more elements are present in a compound, the formula still indicates the atom ratio. To find the formula of a compound we need to find the mass of each of the elements in a weighed sample of that compound.

For example, if we resolved a sample of the compound NaOH weighing 40 grams into its elements, we would find that we obtained just about 23 grams of sodium, 16 grams of oxygen, and 1 gram of hydrogen. The sample of NaOH contains equal numbers of Na, O, and H atoms. Since this is the case, the atom ratio Na: O: H is 1: 1: 1, and so the simplest formula is NaOH. In terms of moles, we have one mole of Na, 23 grams, one mole of O, 16 grams, and one more of H, 1 gram. From this kind of argument we can conclude that the atom ratio in a compound is equal to the mole ratio.

We get the mole ratio from chemical analysis, and from that the formula of the compound. In this experiment, we will use these principles to find the formula of the compound with the general formula CuxCly zH2O, where x, y, and z are integers which establish the formula of the compound. The compound we will study is called copper chloride hydrate. We first drive out the water, which is called hydration. This occurs if we gently heat the sample to a little over 100*C. The compound formed is anhydrous (no water) copper chloride.

If we subtract its mass from that hydrate, we can determine the mass of the water that was driven off, and using the molar mass of water, find the number of moles of H_2O that were in the sample. Next, we need to the find either the mass of copper of chlorine in the anhydrous sample we have prepared. (It is easier to find one mass and find the other by difference.) We do this by dissolving the anhydrous sample in water, which gives us a green solution. To that solution we add some aluminum metal wire, which will react to the ions, converting them to copper metal. As the reaction proceeds, copper metal will appear on the aluminum wire with typical red-orange color. When the reaction is complete, we remove the excess Al, separate the copper from the solution, and weigh the dried metal. From its mass we can calculate the number of moles of Cu in the sample. We find the mass of Cl by subtracting the mass of Cu from that of the anhydrous copper chloride, and from that value determine the number of moles of Cl. The more ratio for Cu: Cl: H_2O gives us the formula of the compound. Experimental Weigh a clean, dry crucible, without a cover, accurately on the analytical balance. Place about 1 gram of the unknown hydrated copper chloride in the crucible.

Then weigh the crucible and contents on the balance. Enter results on the Data page. Place the uncovered crucible on a clay triangle supported by an iron ring. Light your Bunsen burner away from the crucible, and adjust the burner so that you have a small flame. Gentely heat the crucible as you more the burner back and forth. Do not overheat the sample. As the sample warms, the color will change from blue-green crystals to the anhydrous brown form. After all the crystals are brown, remove the burner, cover the crucible to minimize rehydration, and let cool for 15 minutes.

Finally, weigh the cool uncovered crucible and contents. Transfer the brown crystals in the crucible to a 50-mL beaker. Rinse out the crucible with two 5-

mL portions of distilled water, and add rinsings to the beaker. Swirl the beaker to dissolve crystals. The color will change to blue-green as the copper ions are rehydrated. Take about 20cm of 20-guage aluminum wire (~0. 25g) and form the wire into a loose spiral coil. Immerse the coil into the solution. As the copper ions are reduced, the color of the solution will fade. The reaction will take about 30 minutes to complete.

The solution will be colorless and most of the copper metal that was produced will be on the Al wire. Add 5 drops of 6M HCl to dissolve any insoluble Al salts and clear up the solutions. Use your glass stirring rod to remove the copper from the wire. When finished, put the wire aside. In the beaker, you now have metallic copper in a solution containing aluminum salt. Next, we will use a Buchner funnel to separate the copper from the solution. Weight accurately a dry piece of filter paper that will fit the Buchner funnel, and record its mass. Put the paper on the funnel; apply light suction as you add a few mL of water to ensure a good seal.

With suction on, decant the solution into the funnel. Wash the copper metal thoroughly with distilled water, then transfer the wash and all of the copper to the funnel. Rinse the copper of the paper once more and turn off suction. Add 5-mL of 95% ethanol to the funnel. After a minute or so, turn suction back on. Draw air through the funnel for about 5 minutes. With your spatula, lift the filter paper from the funnel. Dry the paper and copper under a heat lamp for 5 minutes. Allow it to cool to room temperature and then weigh it accurately.

Results Atomic Masses:

Discussion

The significance and relevance of the experimental results is that I was able to determine the chemical formula for the unknown compound, which was copper chloride hydrate. By finding out the mole ratio, I was able to find out the chemical formula. My results were precise and accurate. My results were expected, and gave me the answer CuCl2 (dehydrated sample) and CuCl2 2H2O (hydrated sample).

Conclusion The experiment went as planned. During dehydration, the color changed from blue-green to brown (anhydrous), and returned back to blue-green when water was added. When the aluminum wire was added to the solution, the copper ions were reduced to the metal, and the wire was changed to a red-orange color. From the mass calculations of the samples, I was able to find the number of moles. With mole ratio of the hydrated and dehydrated, determining the chemical formula for each was easy. The conclusion is that it is possible to find the chemical formula of an unknown compound.