CHEMISTRY 075

WATER OF HYDRATION

INTRODUCTION

Solids that contain water molecules as part of their crystalline structure are known as hydrates. Water is chemically bound in a compound, usually ionic, so that the water molecules become part of the crystal structure and are present indefinite proportions relative to the other ions.

In this lab we will take a hydrated compound and accurately determine the initial mass. We will then heat the hydrated compound to remove the water. We will then accurately determine the weight of the anhydrous barium chloride. Assuming the loss in mass is the mass of the water of hydration, the mole ratio of water to barium chloride can be determined and subsequently the formula of the hydrate. The difference in the mass of the hydrated compound and the subsequent mass of the anhydrous compound will be the mass of water removed. We will use these measurements to determine the formula for the hydrated compound.

The purpose of this laboratory exercise is to find the mole ratio of water to barium chloride in a hydrate of barium chloride, $BaCl_2 \cdot nH_2O(s)$. The percentage composition of the hydrate has experimentally been found to be 56.22% barium, 29.03% chlorine, and 14.75% water.

THEORY

Water molecules are held in a hydrated compound by electrostatic forces between polar water molecules and the positive or negative ions of the compound. These forces are weaker than covalent or ionic bonds. As a result, water of crystallization can be removed by heating a hydrated crystal.

For example:

$$CuSO_4 \cdot 5H_2O(s) \rightarrow CuSO_4(s) + 5H_2O\,(g)$$

$CuSO_4(s)$ crystals without any combined water are called anhydrous copper (II) sulfate. On standing in moist air, the anhydrous crystals will take on water from the air until copper(II) sulfate pentahydrate is formed.

Many anhydrous slats readily absorb water from the atmosphere. Such substances are said to be hygroscopic. Some compounds continue to absorb water beyond the hydrate stage and form solutions. A substance that absorbs water from the air until it forms a

solution is said to be deliquescent. A few granules of anhydrous calcium chloride or pellets of sodium hydroxide exposed to the air will appear moist in a few minutes and within an hour will absorb enough water to form a puddle of solution.

PROCEDURE

1. Choose a crucible with a proper fitting lid. The crucible should be handled only with tongs during the experiment. The crucible should be placed on a porcelain plate when being moved or cooled.
2. Place the covered crucible in a clay triangle that is on an iron ring clamp attached to a retort stand. Adjust the height of the ring so that the bottom of the crucible will be just above the cone in the Bunsen burner flame.
3. Heat the covered crucible for at least two minutes. The bottom of the crucible should attain a red-hot glow during this time. Turn off the Bunsen burner flame and allow the crucible to cool on the clay triangle for about 5 minutes.
4. Using crucible tongs, place the cooled crucible and lid on a porcelain plate.
5. While on the porcelain plate, transport the crucible and lid to the balances. Using an analytical balance, weigh the crucible and lid to the nearest 0.0001g. Remove the crucible and lid from the balance.
6. While using the same balance as in Step 5, place a weigh boat on the analytical balance. Tare. Add between 3-4 grams of $BaCl_2 \cdot nH_2O$ (s) to the weigh boat. Remove the weigh boat and barium chloride hydrate from the balance and transfer the barium chloride hydrate into the weighed crucible.
7. Using the same analytical balance, weigh the crucible, lid and barium chloride hydrate to the nearest 0.0001g.
8. Return to the Bunsen burner station with the crucible, lid and barium chloride. Use the porcelain plate for transport.
9. Using crucible tongs, place the crucible on the clay triangle. Place the lid on the crucible at an angle to allow water to evaporate.
10. Using the Bunsen burner, heat the partially covered crucible and contents VERY GENTLY for five minutes. Then increase the flame and heat for 15 minutes.
11. Cover the crucible completely with the lid and allow it to cool for 10 minutes. (Note: if you do not cover the barium chloride at this point it will absorb water from the air).
12. Use the porcelain plate to transport the crucible, lid and contents to the analytical balances. Using the same analytical balance, reweigh the barium chloride, lid and crucible. Record this weight to the nearest 0.0001g.

DATA

All of the weights recorded should be to the nearest 0.0001g.

Your data should include:

1. Mass of the crucible and lid
2. Mass of crucible, lid and $BaCl_2 \cdot nH_2O$ (s)
3. Mass of crucible, lid and $BaCl_2$

ANALYSIS

Your calculations should include:

1. Mass of H_2O (g) released
2. Mass of $BaCl_2$
3. The mole of barium chloride present
4. The mole of water released
5. 3 and 4 above will provide you with the mole ratio of $BaCl_2$ to H_2O present in the hydrated compound
6. Divide the mole of $BaCl_2$ present and the mole of H_2O present by the smaller value. This should result in one value being 1 and the other being a multiple thereof. This will provide you with the correct formula for $BaCl_2 \cdot nH_2O$.

CONCLUSION

State the experimentally determined formula for the hydrate of barium chloride.