Your Very Own Borate Glass

One of the facets of material sciences is glass—with this experiment you will be producing glass samples and performing measurements akin to those performed in a scientific study.

This experiment will teach about glass formation, chemical transitions, and phase changes.

Setup:

1. Place the lab stand on a working surface and attach the bosshead clamp three-fourths of the way up the lab stand.
2. Attach the extension clamp onto the open end of the bosshead so a ninety degree angle is formed between the lab stand and the extension clamp.
3. If the working surface is not heat resistant, position the desired heat-resistant material underneath the extension clamp, where the crucible will sit during the experiment.

Experimental Procedure:

1. Take one ceramic crucible and inspect it for cracks or breaks. Weigh the empty crucible and record the mass.
2. Zero out the scale.
3. Measure 6 grams of boric acid powder using the scoopula and deposit in the crucible. Record the compound weight.

Weight of crucible (grams)	
Weight of boric acid (grams)	

4. If a colored reaction is desired, measure out the necessary amount of the secondary compound and deposit in the crucible. Record the weight. The table below gives the approximate measurements:

Compound	Weight (grams)	Final color
Copper oxide(CuO)	.01-.005	Gray/turquoise
Iron oxide(Fe_2O_3)	.005	Dark red

Compound used	
Weight of compound (grams)	

5. Measure the crucible and powder.

Pre-mix weight (grams)	

6. Mix the powder for one minute to ensure that no large clumps of powder remain. If another compound has been added, mix for an additional 3 minutes.
7. After mixing, weigh the crucible again to get the final weight.

Post-mix weight (grams)	

8. Insert the crucible into the extension clamp's grip, tightening the clamp's slide enough to hold the crucible tightly, but not enough to put too much stress on the crucible.
9. **PUT ON GOGGLES AND HEAT-PROOF GLOVES.**
10. Test the propane blowtorch before operation.
11. After testing, begin to heat the base of the crucible. Start a timer as soon as the flame hits the crucible. (*Note: Heating the crucible too fast could cause it to break, as ceramics are sensitive to drastic temperature changes.*) Turn the blowtorch's propane release a quarter turn, showing a bright blue flame. Pass the flame in a sweeping motion at the base of the crucible, keeping the nozzle of the blowtorch about three inches away from the crucible's base. Consult video for an example.
12. After one minute, move in closer to the crucible, making tight circular motions around the sides and base of the crucible. Keep the nozzle of the blowtorch one inch away from the crucible. Consult the video at spsnational.org/outreach for an example. **DO NOT PUT YOUR FACE CLOSE TO THE CRUCIBLE.**
13. Continue to heat for another 6-10 minutes. Stop heating once steam stops releasing from the crucible, or the glass begins to boil over the top of the crucible. If this occurs, discontinue heat for one minute, then resume.
14. Once steam stops releasing, turn off the blowtorch and set aside. **DO NOT REMOVE PROTECTIVE EQUIPMENT.**

15. The crucible will take about 30 minutes to cool down. During this time, the glass will cool down, releasing the last bit of trapped air/steam. **The glass may crack and eject small shards. Do not get too close to the crucible until cool, and do not remove protective equipment.**
16. Once fully cooled, remove crucible from the extension clamp and admire your work. You have successfully made a borate glass!

Analysis:

Weigh the crucible once cool.

Final crucible weight (grams)	
Time spent heating	

Take the measurement for the final crucible weight and subtract the initial weight of the empty crucible. This is the weight of the product: glass.

Weight of glass (grams)	

How can this be? The starting weight of the added compounds was 6 grams—there was some significant loss. The reason for this lies in the chemical equation:

$$2H_3BO_3 \overset{\Delta}{\rightarrow} B_2O_3 + 3H_2O$$

According to the equation, there will be water loss in the final product—leaving only the glass behind.

Now for something a little different—a major component in scientific study is determining whether your data is good or not. To determine whether the glass was produced correctly, you will do a weight loss. For the purpose of this analysis, only the equation above will be used—the colorant compound is negligible.

To start, in a perfect scenario there would be no burn-off or excess water left behind—only by making the glass in a vacuum this would occur. We will begin by calculating the ideal weight loss. Consult a periodic table to find the weight of each element in one mol—the atomic mass unit.

Element	Atomic mass unit (AMU)
H	
B	
O	

Now reconstruct the mass of the reactant.

Compound	Atomic mass (AMU)
H_3BO_3	

For each compound, the mass of the atom used, multiplied by the amount of times it occurs in each compound, then added together will give the final atomic mass of the compound. For example, boric acid is composed of three hydrogen, one boron, and three oxygen. To get the final atomic mass of the compound, the atomic mass of three hydrogen, one boron, and three oxygen would be added together.

Now, the atomic masses of the products is needed, done exactly the same way as before:

Compound	Atomic mass (AMU)
B_2O_3	
H_2O	

Add the two products together—make sure they equal the reactant amount. From here, the actual weights of each product can be calculated. In the perfect reaction, 6 grams of boric acid should be reacted to produce the borate glass and water.

With that in mind, the atomic mass of the boron oxide and water can be multiplied by 6 to receive their final weights:

Compound	Weight (grams)
B_2O_3	
H_2O	

With this in mind, the weight of the water will be the weight of the loss in this system. Calculate the weight loss of the experimental sample and compare results. Why do you think your number is higher/lower than the calculated value?