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Experiment #3: Weight Analysis of a Copper Oxide

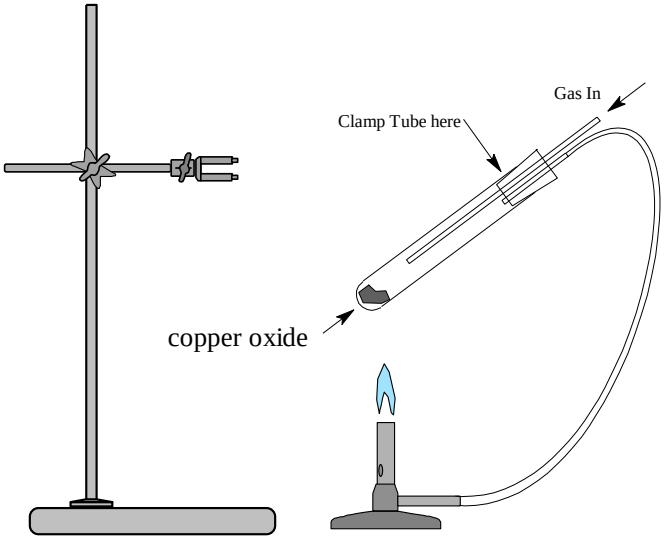
Some metals, such as gold and silver, are naturally found in their elemental form and have been used since prehistoric times. Other metals, such as mercury, can be isolated from their oxides simply by strong heating. Many more metals can be produced by strongly heating the oxides with a reducing agent such as carbon, which transfers electrons to the metal cation. In today's lab, we will use methane gas as a reducing agent, as it is faster and cleaner than charcoal. The empirical formula of an oxide of copper and the mass percentage of copper in the oxide will be determined using the weights of the metal and the oxide according to the following unbalanced chemical equation:

$$Cu_xO_y(s) + CH_4(g) \rightarrow Cu(s) + H_2O(g) + CO_2(g)$$

Be aware that there are several forms of copper oxide with formulas that depend on the charge of copper; you will determine the formula for one of these forms.

Procedure

1. Arrange the apparatus as shown in the following schematic. The gas delivery tube should reach to about 5 cm (2 inch) from the bottom of test tube.



Keep tube at 45° angle!

Stop heating if tube glows orange!

Make sure stopper is on snugly!

Use a foil wrapped stopper!

2. Weigh a clean, dry heavy walled (Pyrex) 200 mm ignition tube on the balance. The tube should have straight sides. If it has a flanged open end (i.e. flared out), don't use such a tube, it will melt in the heat!

3. Weigh about one gram of your copper oxide on a piece of paper or in a plastic tray. (You *do* need to know the exact weight of the powder.) Pour this sample through a funnel with an extension into the weighed test tube. Use the funnel to keep the copper oxide off the sides of the test tube.

4. Weigh and record the mass of the test tube and copper oxide.

5. Connect the test tube to your apparatus. CAUTION: do NOT use plastic coated clamps as they will melt. Use the fiberglass "mitts" to cover the clamps. Check with your instructor for approval before proceeding any further.

6. Turn on the natural gas (methane) slowly. Light and adjust the flame of the Bunsen burner and heat the sample of copper oxide with your burner. Continue to heat the sample with as hot a flame as possible for about 20 minutes or until it turns completely copper colored. If the tube starts glowing orange, pull the Bunsen burner away for awhile. If you heat the tube for too long, it will develop a soft spot and eventually pop open!

7. After the heating is completed, turn off the Bunsen burner but do NOT remove the stopper from the test tube until it is cool enough to hold with your hands. Warm samples may reoxidize if exposed to air.

8. Weigh the tube and contents.

9. Reheat the system for 10 more minutes, let it cool, and reweigh it. If the weight remains the same (within 0.005 g) as the last weighing, you are done. Otherwise, reheat for an additional 10 minute period until the weight of the pellet and tube remain constant for two consecutive weighings.

10. After you have weighed the pellet, dispose of it in the proper waste container.

11. [Optional] Place the pellet on the benchtop and cover it with a tissue or paper towel. Press down on it and slide it back and forth across the benchtop. The pellet will quickly become hot from the friction. Once it is very hot, turn it over and examine the polished surface.

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Data and Calculations

Mass of empty test tube: _____

Mass of the test tube + copper oxide before heating _____

Mass of the test tube + solid after 20 minutes of heating _____

Mass of the test tube + solid after 30 minutes of heating: _____

Mass of the test tube + solid after 40 minutes of heating:* _____
*if necessary; add more lines if needed

Mass of the copper oxide *before* you heated: _____

Final mass of the copper metal powder: _____

Mass that disappeared during the heating: _____

What element or compound disappeared
from the copper oxide during heating? _____

Moles of copper in the pellet: _____

SHOW CALCULATION:

Moles of oxide that escaped: _____

SHOW CALCULATION:

Empirical formula of the initial copper oxide: _____

SHOW CALCULATION:

Mass percentage of copper in copper oxide: _____

SHOW CALCULATION:

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Post-lab Questions

1. Write the balanced chemical equation for the reaction of your oxide using the experimentally determined empirical formula.

2. Imagine you had just discovered copper. Which of the following formulas would be *possible* guesses (however unlikely) for the empirical formula of copper oxide? Which would be *good* guesses if you used the periodic table as a guide to understanding copper's probable charge? Briefly explain your choices below.

   $Cu_{10}O$ Cu_5O Cu_3O_2 Cu_2O

   CuO Cu_2O_3 CuO_2 CuO_{11}

3. A sample of an iron oxide weighing 1.996 g yields 1.396 g of iron on reaction with methane gas. Determine the percent composition and the empirical formula of the iron oxide from this data. SHOW ALL CALCULATIONS! Random guessing will NOT earn you any credit.