EXPERIMENT 12: Recovery of Copper from Solution and Reaction of Cu with O_2 to form an Oxide of Copper.

Introduction.

A solution of copper sulfate will be reacted with zinc metal. Metallic copper will precipitate, and zinc metal goes into solution to replace the copper. Just enough zinc will be added to the $CuSO_4$ to precipitate out the copper. This must be done with some care so as to not add too much zinc.:

$$Zn + CuSO_4 \longrightarrow Cu + ZnSO_4$$

The precipitated copper metal can be dried and weighed, and the percent of copper in the original solution can be calculated. Assuming that the copper sulfate solution had a density of 1.00 g/mL, the 100 mL weighs 100 g and the percentage is calculated as follows:

$$\% Cu = \frac{\text{g Cu recovered}}{\text{100 g of } CuSO_4 \text{ solution used}} \times 100$$

Materials: 250 mL beaker, evaporating dish, burner, iron ring, wire gauze, Zn (s), $CuSO_4$(aq),

Heating the copper in the evaporating dish will produce copper oxide. Which oxide is produced can be found by the ratio of moles Cu / moles O. (x/y) . Experimentally of course the student will not obtain an exact ratio such as 1:1 or 2:1 or 2:3 but some value close enough to draw a conclusion about the formula of the copper oxide. A mixture of oxides may form

$$x\ Cu + {}^{y}/_{2}\ O_2 \rightarrow Cu_xO_y$$

Do **all** weighings to 4 Decimal places

Procedure:

Part 1. Preparation of copper.

a) Carefully measure $CuSO_4$ solution to the 50.0 mL mark. Pour the 50.0 mL into a clean dry 250 mL beaker. Repeat – such that you now have 100.0 mL of $CuSO_4$ solution in the beaker.

b) Weigh a small watch glass to 4 decimal places. Pour about 1 g granular zinc on the glass. Weigh the zinc with the watchglass to 4 decimal places.

c) Set the beaker on a ring stand on top of a wire gauze and heat gently with a Bunsen burner to about 50°C. DO NOT BOIL. Turn off the flame. Add about half of the granular zinc to the beaker and stir 2 minutes. Turn on the flame again and heat gently , keep stirring and add small portions of the Zn with your spatula, until the blue or green color of the copper sulfate disappears. If the blue color does not disappear, after most of the zinc has been added, heat again with stirring .

d) Weigh the watchglass with the left-over Zn.(4 dec places)

e) Carefully pour off most of the solution, without losing any of the solid, and discard the liquid. Add about 50 mL of deionized water to the remaining mixture. Again, pour off the liquid and retain the solid in the beaker. Repeat with one more washing.

f) Weigh a clean dry evaporating dish (4 decimal places). .

g) Transfer the solid from the beaker to the evaporating dish, using small rinse portions of water from your wash bottle. Pour off as much of the water as possible into another beaker. Discard the washings.

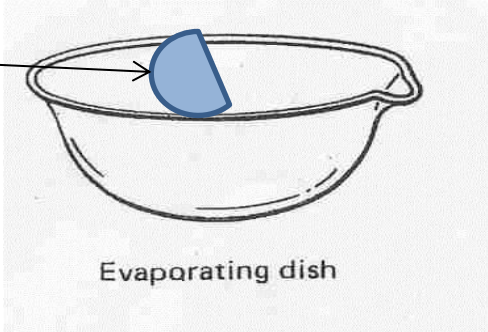
h) Do a final rinse of the precipitate with a small portion – about 5 mL – of acetone. Pour it off

i) Take a small piece of paper towel and place it in the copper so only a small portion of the paper touches the copper and let the Cu air dry in your locker until the next la period. Remove the paper and weigh the dish with the Cu and calculate the grams of Cu recovered. (See figure 1)

j) Calculate the percent of Cu in the original 100.0 mL of $CuSO_4$ solution. Show your set-up Watch your sig figs in the calculation. Save about half the copper in the evaporating dish for Part 2. Weigh the remainder. Place about ½ the sample in a labeled vial (label #1 see below)

k) Purity test. Take a small sample of Cu from the dish (a small portion on the tip of the spatula) and place it in a test tube. Add about 5 mL of 3M sulfuric acid and make an observation.

Figure 1. paper segment should contact the Cu



Label #1 for vial

Forgetful Freddie
Sample: y.yyyy g
(4 decimal places)

Label #2 for second vial

Forgetful Freddie
Copper oxide
z.zzzz g (4 dec pl)

Part 2. Combination of copper with oxygen.

a) Weigh the dish with the remaining copper – (half the sample which was not placed in a vial or tested)

b) Place the dish with the copper on a wire screen on an iron ring above a Bunsen burner. Heat strongly for 5 minutes. What do you see happening in the dish – keep your eyes on it while heating. ? Using your spatula, scrape the solid while heating, to expose fresh surface to the air. Heat 5 more minutes with stirring then turn off the flame. Let cool 5 minutes. Carefully remove the dish with beaker tongs (not crucible tongs) and place it on another wire screen for further cooling to room temperature.NEVER PLACE A HOT ITEM DIRECTLY ON THE DESKTOP or on the ringstand base. (Ringstands and desks have paint which will stick to a hot item)

c) When the dish with copper oxide has reached room T, carefully weigh it and calculate the grams of copper oxide (4 dec places) Transfer your sample to a vial and cork it. Place a and write your name, # grams of sample in the vial. SUBMIT BOTH PRODUCTS TO THE INSTRUCTOR !! NO SAMPLES – NO CREDIT !!. Tie a rubber band or cellotape around the two vials such that the labels are visible. Extra vial is available at the stockroom.

Calculations.

Using the atomic mass of copper = 63.546, you can calculate the moles of copper obtained. The increase in the mass of the sample will be the mass of the oxygen incorporated by the copper. (procedur 2c)
The atomic mass of oxygen is 16.00
The moles of copper / moles oxygen will give you a mole ratio x/y.

You can round off the mole ratio and determine which oxide of copper was produced. For example:
Cu_2O CuO Cu_2O_3 CuO_2 Where Cu could have charges of +1, +2, +3, +4
And of course O has a charge of -2 .

A mixture of Cu_2O and CuO may form – with the apparent formula Cu_3O_2

EXPERIMENT 12 (Rev). Name : _____
Recovery of Copper from Solution Section _____ Due date: _____
and Synthesis of Copper Oxide

Part 1. Data

Part a) volume of copper sulfate solution used: _____

Part b)
Masss of watch glass: _____ Mass of watch glass with Zn _____ Mass of Zn _____

Part d)
Mass of watch glass with remaining Zn after reaction. _____ Mass of remaining Zn _____

Calculate: Mass of Zn used _____

Part f) Mass of evaporating dish : _____ Part i) Mass of dish with copper: _____

Calculate the grams of recovered copper: _____

Observations.

Describe the appearance of the $CuSO_4$ solution before adding zinc Describe the color of the solution after you have heated it with granular zinc for a while

Describe the appearance of the dried copper sample.

Purity test with sulfuric acid – what did you see happening (if anything) ?

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Part 2. Data & Observations.

Describe what you see happening in the dish as the copper is heated. Describe the appearance of the sample during and after heating

Part a) After scooping out about ½ the Cu : Mass of dish with remaining copper _____

Part c) After the reaction and cooling: Mass of the dish with the copper oxide. _____

Calculations

Part 1. Using the total grams of copper recovered (part i)
Calculate the percent of copper in the solution. (show setup – use the formula on page 1). _____%

Part 2.
Using the sample left in the dish

a) Calculate the grams of copper used _____

c) Calculate the grams of copper oxide _____

Calculate the grams of oxygen incorporated by the copper _____
(the mass gained = mass of oxygen).

Analysis :

Calculate the moles of copper used (part 2a). _____ watch sig figs
(show setup)

Calculate the moles of oxygen incorporated by the Cu. _____
(show setup)

Calculate the mole ratio of Cu / O _____
(show setup with appropriate sig sigs)

Conclusion: What is the formula of the copper oxide ? _____
(round to a whole # ratio)

Questions

1. From the mass of zinc used in the reaction (initial g Zn – final g Zn in part 1d) calculate the theoretical yield of copper which should precipitate.

2. Calculate the percent yield of copper $\frac{\text{(actual yield (part 1f)}}{\text{(theoretical yield)}} \times 100$

3. Why is it important to rinse the solid copper with several portions of water?

. 4. If you obtained greater than 100 % yield (question 2) and assuming the sample was dry, what may have occurred ? (try to answer this – even if your yield was not more than 100%)

5. Explain any observations when you did the purity test. Use equation(s) to illustrate. Refer to question 4 if you saw something.