Balancing Investigation

A Circle of Copper Compounds

Starting with copper(II) sulfate pentahydrate, CuSo₄5H₂O, a series of reactions illustrates the ease with which some metal compounds can be formed and destroyed, finally reproducing the original material. The product of this Investigation is saved to become the starting material for the next one.

**Equipment you will need:** **Chemicals you will use:**

* Beakers, 100 and 600ml Copper(II) sulfate pentahydrate, CuSo₄5H₂O
* Hot plate Hydrochloric acid, HCl, 3*M*
* Evaporating dish Sodium carbonate, Na₂Co3, 1*M*
* Stirring rod Sodium hydroxide, NaOH, 3*M*
* Wash bottle Sulfuric acid, H₂SO₄, 1.5*M*

**Other Items**

Conductivity meter

Litmus paper, red and blue

Baking soda to neutralize “unwanted chemicals” solution

**BEFORE YOU BEGIN**

1. Read procedure and write reactants for each chemical reaction
2. Predict products for each reaction
3. Balance each reaction

**SAFETY NOTES**

1. Wear approved safety goggles and gloves
2. The following acids and bases are CAUSTIC and must be used with care:
   1. Hydrochloric acid, HCl, 3M
   2. Sodium hydroxide, NaOH, 3M
   3. Sulfuric acid, H₂SO₄, 1.5*M*

These materials, though dilute, can burn your skin. If you get any of these on your skin or clothing, rinse with running water *immediately* and tell your teacher.

1. All chemicals must be handled carefully and treated with respect. The solids and liquids used in this Investigation are safe for you to use responsibly.
2. Copper compounds are toxic if ingested. Handle them carefully.
3. Wash your hands before you leave the lab.

PROCEDURE: **EVERYTHING THAT IS UNDERLINED NEED TO BE ANSWERED OR COMMENTED ON ON YOUR OBSERVATION PAGE.**

1. Determine and record the mass of evaporating dish, and then add about 1g of copper(II) sulfate pentahydrate, CuSo₄5H₂O. Record the mass of the evaporating dish + salt to the nearest 0.01g on the Observations page.
2. Add about 5 mL of water, and stir to dissolve the salt. What color is the solution? If the salt is slow to dissolve, place the beaker on a hot plate and heat the solution gently with stirring.
3. RXN 1: Allow the solution to cool, and then add 5 mL of 1*M* sodium carbonate, Na₂Co3, and stir. Record what happens. What is the product?
4. RXN 2: Add HCl drop wise until reaction is complete. Record the amount of HCl used. What happens? What gas is being produced?
5. RXN 3: Obtain 10 mL of 3*M* sodium hydroxide, NaOH. Add it with stirring to the solution in the evaporating dish. Describe the result.
6. RXN 4: Heat the mixture gently with stirring. Do not stop stirring, because bubbles tend to form under the precipitate, and they can rise violently to the surface, bumping solution out of evaporating dish. (Why does stirring prevent bumping?) What is happening to the precipitate? What compound do you think is forming?
7. When the color change is complete and bubbling is visible at the bottom of the evaporating dish, stop heating and stirring, and allow the precipitate to settle, rinsing down any solid on the sides of the evaporating dish with a little water from a wash bottle. This may take 10-20 minutes. What color is the supernatant liquid? (while the precipitate is settling, start writing the equations on page 6.)
8. Using the technique your teacher has showed you, carefully decant the supernatant liquid into a 600-mL beaker, retaining the precipitate in the evaporating dish. Set aside the solution in the beaker to collect other unwanted items.
9. Spray and wash the products with distilled H₂O to the precipitate and stir the precipitate well to rinse it. Let the precipitate settle again. Decant once more into the 600mL beaker, retaining the precipitate in the evaporating dish.
10. RXN 5: Wash again but while missing, pour all of the H₂O and product into the evaporating dish. Then let it settle. Decant again into the 600mL beaker. To the precipitate in the evaporating dish, slowly add 6mL of 1.5*M* sulfuric acid, H₂SO₄, with constant stirring. Warm gently until solution is complete and blue again. What is the product?
11. Set the evaporating dish on a hot water bath. Allow the solution to cool. Set it aside overnight to allow cystals to form.
12. Determine the mass of evaporating dish plus crystals and, following instructions on the Results page, compute the quantity of CuSo₄5H₂O you recovered and your percent yield.
13. Check the liquid in the 600 mL beaker to see if it is neutral. If so pour it down the drain, if not, add baking soda if acidic and vinegar if basic, to neutralize the solution. Test pH of solution until it reaches a seven. Pour down the sink, and flush the resulting solution down the drain.
14. Return all chemicals to their proper places in the lab and wash and dry all of your materials.

**OBSERVATIONS**

Almost every step of the Procedure requires that your make observations. Set up your Observations page to record masses, and answer the questions that are in the Procedure. Number your observations to correspond to steps in the Procedure. Write the names and formulas of products formed in every case.

**RESULTS**

1. How did the quantity of CuSo₄5H₂O you recovered compare to the mass of the starting material?
2. What is the theoretical yield of CuSo₄5H₂O?
3. Using the theoretical yield in #2 above and you actual yield, compute your percent yield. Justify your answer.

**FOLLOW-UP QUESTIONS**

1. What was the purpose of adding water to the black CuO precipitate, then decanting, and rinsing? Why was this repeated a number of times?
2. If your started with 1.000g of CuSo₄5H₂O, how many grams of dry CuO could you expect to make? ( HINT: look at the equations you have written on page 6, and determine the mole relationship between the starting material and CuO.)
3. Brad begins an Investigation by reacting 10g of calcium chloride hexahydrate with an excess of potassium hydroxide, KOH. His partner, Dawn, then add the excess sulfuric acid H₂ So₄, to react with the calcium hydroxide. Brad then adds a solution of sodium phosphate, ot precipitate calcium phosphate.
   1. Write an equation for each step of Brad’s and Dawn’s experiment.
   2. When Dawn Dries and determines the mass of calcium phosphate, how much should she have?