Copper Cycle

Chemists in industry often use stepwise procedures involving a sequence of chemical reactions to obtain a desired product. In the sequence the available starting materials change in a number of steps. In this experiment you will study a stepwise sequence of several reactions which begins with solid copper, follow the copper through different chemical steps and end with the recovery of solid copper. The sequence of chemical reactions involves different types of chemical reactions. The law of Conservation of Matter states that matter can be neither created nor destroyed, so you should recover the same mass of copper at the end. This assumes that all steps were performed with 100% efficiency. You will test your efficiency by using the initial mass of copper to determine the percent yield of $\text{CuO}$ and percent recovery of copper.

Procedure

Part A

1. Obtain a piece of copper foil (~0.2 – 0.3 g) and record its exact mass to 0.1 mg. Avoid handling the copper with your fingers.

2. **Working in the fume hood**, place the foil in a 250-mL beaker and add 8 mL (graduated cylinder) of 6 M $\text{HNO}_3$.

3. When the copper has completely dissolved, carefully add 35 mL of distilled $\text{H}_2\text{O}$ to the copper(II) solution.

Part B

4. Measure 12 mL of 4 M $\text{NaOH}$ into a small graduated cylinder.

5. Using a disposable pipet, add the $\text{NaOH}$ solution dropwise to the copper(II) solution with swirling between each drop. Continue to add the $\text{NaOH}$ solution until a precipitate remains. Allow the light blue precipitate to settle, then add one more drop to the solution to see whether precipitation is complete. **Avoid large excesses of NaOH solution.**

Part C

6. Add enough distilled $\text{H}_2\text{O}$ to give a total volume of approximately 100 mL.

7. Boil the mixture **gently** for 5 minutes, with stirring. When the reaction is complete, remove the beaker from the heat. The solution will be colorless and a black precipitate (CuO) will settle to the bottom of the beaker.

8. Add 10 drops of phenolphthalein indicator. Add one drop of 6 M acetic acid, stir, and let the precipitate settle enough to note the color. Repeat until the magenta
color of the solution just disappears. **Note: if too much acid is added, the precipitate will dissolve. If this happens, return to step 5, skip step 6 then got to 7 and 8.**

9. Weigh a piece of filter paper to the nearest 0.1 mg. Flute the filter paper.

10. Place the filter paper in a gravity funnel that is supported by a metal ring clamped to a ringstand.

11. Pour the solution containing the precipitate into the filter paper. The goal is to get all of the precipitate into the filter paper. A wash bottle can be used to rinse out all of the precipitate into the paper. **If the filtrate is blue, see step 8.**

12. Partially dry the filter paper and precipitate by allowing about 10 mL of ethanol to drain through the paper. Repeat with about 10 mL of acetone.

13. Working outside the hood, carefully remove the filter paper from the funnel. Unfold, and lie flat on three thickness of clean paper towel. Dry under a drying lamp for a few minutes.

14. Weigh the filter paper and precipitate to the nearest 0.1 mg. This will enable you to determine the percent yield of CuO.

**Part D**

15. Obtain 5 mL of 6 M HCl in a small graduated cylinder.

16. Place a clean beaker under the filter apparatus to collect filtrate. Place the filter paper (carefully re-folded to fit) into the funnel.

17. Using a disposable pipet, add the 6 M HCl dropwise on the black precipitate. Collect the green solution in the clean beaker.

18. Using the same pipet, transfer the green solution from the beaker back over the precipitate on the filter paper until the precipitate all dissolves. If undissolved precipitate still remains, wash with fresh 6 M HCl, 1 mL at a time, until no precipitate remains on the filter paper.

19. Finally, wash the filter paper with 5 mL of distilled H₂O, collecting the filtrate in the same beaker.

**Part E**

20. **Working in the hood,** pour 10 mL of 6 M NH₃ into a small graduated cylinder.
21. Using a disposable pipet, add the 6 M NH₃ slowly, with constant stirring to the green solution until all the light blue precipitate, which forms initially, just dissolves.

**Part F**

22. Cautiously add 10 mL of 6 M H₂SO₄ a few drops at a time to the deep blue solution. Handle the solution carefully as it will become hot. After all the H₂SO₄ has been added, the solution will be sky blue.

**Part G**

23. Add about 0.50 g of magnesium turnings to the blue solution.

24. When all the magnesium has all dissolved and the solution is colorless, add 5 mL of 6 M H₂SO₄, stir vigorously and observe carefully for additional bubbles of hydrogen gas. If no hydrogen bubbles form, the reaction is complete.

25. Allow the copper metal to settle to the bottom of the beaker and carefully decant most of the liquid, **being very careful not to lose any of the copper.**

26. Weigh a piece of filter paper to the nearest 0.1 mg. Flute the filter paper.

27. Place the filter paper in a gravity funnel that is supported by a metal ring clamped to a ringstand.

28. Pour the solution containing the copper into the filter paper. The goal is to get all of the copper into the filter paper. A wash bottle can be used to rinse out all of the copper into the paper.

29. Partially dry the filter paper and copper by allowing about 10 mL of ethanol to drain through the paper. Repeat with about 10 mL of acetone.

30. Working outside the hood, carefully remove the filter paper from the funnel. Unfold, and lie flat on three thickness of clean paper towel. Dry under a drying lamp for a few minutes.

31. Weigh the filter paper and copper to the nearest 0.1 mg. This will enable you to determine the percent yield of Cu.

**Questions**

1. Define the following:
   
a. acid–base reaction
b. precipitation reaction

c. oxidation–reduction reaction

2. A student performed the experiment that you are going to do. The data is given below:

<table>
<thead>
<tr>
<th>Mass</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of copper foil:</td>
<td>0.260 g</td>
</tr>
<tr>
<td>Mass of filter paper:</td>
<td>0.525 g</td>
</tr>
<tr>
<td>Mass of filter paper and CuO:</td>
<td>0.834 g</td>
</tr>
<tr>
<td>Mass of filter paper:</td>
<td>0.490 g</td>
</tr>
<tr>
<td>Mass of filter paper and Cu:</td>
<td>0.732 g</td>
</tr>
</tbody>
</table>

Determine the percent yield of CuO and Cu recovered.

**Data Treatment**

1. Write out all of the chemical reactions observed.

2. Determine the percent yield of CuO and Cu recovered.