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A Look at Copper

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The study of copper and its compounds is among the more aesthetically pleasing aspects of chemistry. Copper compounds range in color from white to black, and include virtually all colors of the visible spectrum. The following exercise is designed to explore some of the chemical properties of copper and copper compounds.

STEP I

Scrap pieces of electrical wire provide an excellent, inexpensive and reasonably pure form of copper. Dissolve 10-15 cm of copper wire in 6 M nitric acid (HNO_3) under a fume hood. Yellowish-orange colored NO_2 gas produced in this reaction is quite poisonous and should not be breathed. The unbalanced equation for this reaction is:

$$Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO_2 + H_2O$$

Concentrated HNO_3 (15 M) will hasten the solution process. However, great care must be exercised in handling nitric acid of this concentration. It is a very strong oxidant and is extremely corrosive. It reacts with protein to produce yellow-colored compounds, thus explaining the yellow color of skin that has been exposed to nitric acid.

A drop or two of the blue solution that results from this reaction can be placed on a microscope slide, allowed to dry and examined with a hand lens to observe crystal structures.

STEP II

Treat the solution formed in Step I by first adding 15-20 ml distilled water and then adding 6 M NaOH until the solution is basic (red litmus turns blue). Care must be taken here to make sure that one is observing a blue color in the litmus paper and not the blue color of the copper hydroxide on the litmus paper. This reaction must be kept cool or black copper oxide will form. The equations for the reactions are:

$$\text{(cold)}\ Cu(NO_3)_2 + NaOH \longrightarrow \overset{\text{(blue)}}{Cu(OH)_2} + NaNO_3$$

$$\text{(hot)}\ Cu(NO_3)_2 + NaOH \longrightarrow \overset{\text{(black)}}{CuO} + H_2O + NaNO_3$$

As in Step I, a little of the precipitated material can be set aside for study of the crystalline structure of the material.

STEP III

Allow the precipitate from Step II to settle and decant the liquid. The precipitate should be washed twice more with 15-20 ml distilled water and decanted each time.

To the washed precipitate add 2 M sulfuric acid (H_2SO_4) dropwise until the precipitate just dissolves. The equation for the reaction is:

$$Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

or

$$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

Again, as in Steps I and II, several drops of the resulting solution can be dried for examination of copper sulfate crystals.

STEP IV

At this point the solution is again made basic with 6 M NaOH. To the basic solution add 10 ml of 1 M sodium phosphate (Na_3PO_4) solution. Stir well and examine the crystal structure of the precipitate as before. The equation for the reaction is:

$$CuSO_4 + Na_3PO_4 \longrightarrow Cu_3(PO_4)_2 + Na_2SO_4$$

Test the solution at this point to make sure that it is basic. If necessary, add 6 M NaOH dropwise, stirring after each addition until the solution shows basic to litmus.

Pre-weigh a piece of filter paper and filter the mixture. Wash three times with 10-15 ml distilled water. Discard the filtrate. Dry and weigh the residue. Determine the percent yield, keeping in mind that 63.5 g copper should form 126 g of $Cu_3(PO_4)_2$.

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