Using stoichiometry to predict the mass of silver by reacting copper metal with a solution of silver nitrate in a single replacement reaction.

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Abstract

Stoichiometry is commonly used in chemistry to predict the quantities of chemicals in a reaction. In this experiment, the mass of silver can be predicted by knowing the mass of the copper metal that was reacted with the silver nitrate. The silver obtained by this experiment is in a pure state, and other pure ores can be found using similar experiments in modern metal refining processes. To complete this investigation, a measured mass of copper wire was placed in an excess amount of a silver nitrate solution overnight. The following day, the silver was washed off the copper wire with water and then the solution was filtered using filter paper and a funnel. This left pure silver behind that was measured after the excess solution on the filter paper had evaporated. At the end of this experiment, the percent yield of silver was 96.54% with an actual yield of 0.502g of silver, and a theoretical yield of 0.520g of silver. The stoichiometry calculations were correct, but there were some errors in our experiment. In the decanting processes, we could have lost some silver flakes down the drain. Also, we could have had a low percent yield because we may have had some copper that had not reacted with the silver nitrate.

Great job!

Procedure

The experiment started with measuring the mass of a strip of copper wire on a balance beam and then coiling the wire and submerging the wire in a beaker of silver nitrate while suspended on a glass rod so the coil did not touch the bottom of the beaker. The coil was then left to react overnight. In the following day, the mass of the reacted wire was taken again after rinsing all the silver off the wire with water. The solution, now full of silver, water, and silver nitrate was filtered through a funnel with filter paper. The mass of the filter paper was measured before filtering. Then the filter paper with silver was left overnight. The next day, the mass of the filter paper was recorded and then with all the calculations, one could use stoichiometry to find the predicted about of silver.

Results

Copper Data	Mass (grams)
Mass of copper (before reaction)	2.255
Mass of copper (after reaction)	2.102
Silver Data	Mass (grams)
Mass of filter paper	1.559
Mass of filter paper and silver crystals	2.061

Originally, the copper was a bright copper-orange colour, and the silver nitrate was a clear liquid. After the copper wire and silver nitrate reacted overnight, the copper wire looked almost fuzzy and grey with a crystal looking like substance surrounding the wire and even reaching from the wire to the bottom of the beaker. After the grey crystals which were really silver were washed off, the copper wire had lost its gloss and colour and was dull and matte, with a grey colouring. The copper wire also appeared to be thinner than when the experiment had begun.

Chemical Equation for Reaction

Copper + Silver nitrate $\longrightarrow$ Silver + Copper Nitrate

$Cu + 2AgNO_3 \longrightarrow Cu(NO_3) + 2Ag$

Mass of Copper Reacted

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Mass of copper before reaction – Mass of copper after reaction = Mass of copper reacted

2.255g – 2.102g = 0.153g

0.153g

Theoretical Mass of Silver

$$\text{Mass of copper reacted} \times \frac{1 \text{ mole of Copper}}{\text{Molar mass of Copper}} \times \frac{\text{Mole Ratio of Silver}}{\text{Mole Ratio of Copper}} \times \frac{\text{Molar Mass of Silver}}{1 \text{ mole of Silver}} = \text{Theoretical Mass of Silver}$$

$$0.153\text{g} \times \frac{1\text{molCu}}{63.5\text{gCu}} \times \frac{2\text{Ag}}{1\text{Cu}} \times \frac{107.9\text{gAg}}{1\text{molAg}} = 0.519959055\text{gAg}$$

0.520gAg

Actual Mass of Silver

Mass of filter paper and silver crystals – Mass of filter paper = Actual mass of silver

2.061g – 1.559g = 0.502g

0.502g

Percent Yield of Silver

$$\frac{\text{Actual Yield of Silver}}{\text{Theoretical Yield of Silver}} \times 100 = \text{Percent yield of silver}$$

$$\frac{0.502\text{gAg}}{0.520\text{gAg}} \times 100 = 96.53846115\%$$

96.54%

Discussion

Our experiment went quite well and gave us a pretty great percent yield of silver. This experiment really helped me to understand what a single replacement reaction can actually make. At the end of this experiment, we came out having pure silver which can be a fairly expensive metal in the sense of jewelry, and we created this metal in only a few class periods. Even though our percent yield was not perfect, we did learn what can happen through a single

replacement reaction and that in this experiment, the mass of silver should have been the exact mass of the reacted copper. Although the experiment was very well done, and presented in a fashion that people could range from 95%-105% yields, there is still room for improvement. Mainly, more class time would have helped, because then everyone could be sure that they were not rushing through the experiment. Also, after removing the copper wire after the reaction with the silver nitrate, there were often bits of copper still mixed in to the silver nitrate solution. To get rid of that, more silver nitrate was added to react with the silver, but as a result, the filter paper had residue of silver because of the silver nitrate. The experiment should call to water down the solution before decanting and filtering to ensure no extra mass on the filter paper because of the silver nitrate solution. In this lab, you know for certain that you will end will pure silver based on the original chemical equation and that you will witness a single replacement reaction. The copper and the silver nitrate will react and give you the products of silver and copper nitrate. The results of this experiment also indicate clearly that the theoretical mass of silver should be the same mass as the amount of copper that was reacted in the lab. Though, human error in measuring can play a large factor in the experiment and can affect how much silver will actually be obtained by the reaction.

* stick to error inherent in the procedure, error that was beyond your control.