Morgan Shapiro

October 20, 2012

Period 3

Copper Lab Write Up

Purpose: The purpose of this lab was to see how much copper could be recovered from an initial amount of copper after various reactions were performed on the initial copper. Copper wire was weighed and came to a total of 2.030 grams. After performing five different reactions with copper, a copper precipitate formed. Theoretically, the mass of this copper precipitate should have been equal to the initial 2.030 grams. This is what we were trying to achieve. However, the copper precipitate weighed 13.103 grams.

Quantitative Results:

Mass of copper wire: 2.030 grams

Mass of evaporating dish: 54.142 grams

Mass of evaporating dish with copper precipitate in it: 67.245

Mass of copper precipitate: 13.103 grams

Qualitative Results:

Observations from reaction between copper and nitric acid:

* Solution bubbled and turned blue
* Solution produced a yellow gas that was released into the hood
* Solution sizzled and foamed
* Solution continued to darken in shade of blue
* Copper wire seemed to be broken down and dissolving into the solution

Observations from reaction between copper (II) nitrate and sodium hydroxide:

* Solution had a pH of 13
* Blue precipitate was produced

Observations from decomposition of copper (II) hydroxide:

* As the solution heated, tiny dark blue particles formed and floated in the lighter blue solution
* Solution itself became darker and more gray in color than blue
* Solution turned completely black
* Bubbles formed and popped
* Clear, grayish solution on the top and a black precipitate sitting on the bottom

Observations from reaction between copper (II) oxide and sulfuric acid:

* Solution turned from black to dark green to teal to fluorescent blue
* Precipitate dissolved

Observation from reaction between copper (II) sulfate and zinc

* Solution turned a lighter blue
* Solution sizzled and bubbled
* Reddish brownish precipitate formed on the bottom
* Solution produced an odor – smell of coins

Observations from reaction between zinc and sulfuric acid:

* Solution sizzled and bubbled
* Clear solution on bottom, foam from sizzling and bubbling on the top
* Zinc particles floated from the bottom of the beaker to the top
* Reddish brownish copper precipitate floated (formed in previous reaction)
* Solution was hot

Balanced Net Ionic Equations for Each Reaction:

1. Cu (s) + 4H+ (aq) + 2NO3- (aq) → Cu2+ (aq) + 2H20 (g) + 2NO2 (g)
2. Cu2+ (aq) + 2OH- (aq) → Cu(OH)2 (s)
3. Cu(OH)2 (s) → CuO (s) + H20 (l)
4. CuO (s) + 2H+ (aq) → Cu2+ (aq) + H20 (l)
5. Cu2+ (aq) + Zn (s) → Zn2+ (aq) + Cu (s)
6. Zn (s) + 2H+ (aq) → H2 (g) + Zn2+ (aq)

Calculations:

* Final Mass of Copper = Mass of Evaporating Dish and Copper – Mass of Evaporating Dish  
  Final Mass of Copper = 67.245g – 54.142g  
  Final Mass of Copper = 13.103g
* Final Moles of Copper:

|  |  |  |
| --- | --- | --- |
| 13.103g Cu | 1 mol Cu | = 0.20618 mol Cu |
|  | 63.55g Cu |

* Initial Moles of Copper:

|  |  |  |
| --- | --- | --- |
| 2.030g Cu | 1 mol Cu | = 0.03194 mol Cu |
|  | 63.55g Cu |

* Percent Yield:  
   = = 645.5%

Conclusions:

The initial amount of copper wire had a mass of 2.030 grams. When converted into moles, the amount of initial copper was 0.03194 moles of copper. The final amount of copper precipitate had a mass of 13.103 grams. When converted into moles, the amount of final copper was 0.20618 moles of copper. The percent yield of copper was 645.5 percent. It can be concluded that there were other compounds contained within the copper precipitate because, as part of the Law of Conservation of Mass, mass cannot be created or destroyed. According to this law, there cannot be more than 2.030 grams of copper in the precipitate. Therefore, other compounds were present and added to the mass of the precipitate.

While the water from the copper precipitate was evaporating during the steam bath, a hard, white crust formed on top of the outer copper. It can be concluded to be an aqueous ionic salt. As the water evaporated from the evaporating dish and copper precipitate, the water in which the ions were dissolved in left. The ions were left and formed a crust. It can be concluded to be an aqueous rather than a solid salt for this reason. If it had been as solid salt, there would have been no change in appearance of the copper because its ions stay together whether they are in an aqueous solution or not. The only aqueous ionic salts present in the products of the reactions are copper (II) nitrate, sodium nitrate, and zinc sulfate. The crust could not have been copper (II) nitrate because the copper formed a precipitate in the last reaction. All of the copper was concentrated in that precipitate. Therefore, the ionic crust was either sodium nitrate or zinc sulfate.

Discussion of Theory:

There were three basic types of reactions that occurred during the lab: oxidation-reduction, single replacement, and double replacement reactions. In order for the experiment to be successful, the criteria required for a reaction to occur in each of the three types must have been satisfied. For oxidation reduction reactions, like the reaction between copper and nitric acid, charges had to change in order to ensure that at least one oxidation and one reduction reaction occurred. The charge of copper changed from 0 on the reactant side to 2+ on the product side, so copper was oxidized. It lost electrons therefore gaining in charge. The charge of nitrogen changed from +5 on the reactant side to +4 on the product side in the compound NO2. Nitrogen gained electrons therefore losing in charge. In order for a single replacement reaction to occur, like the reaction between zinc and sulfuric acid, the single element must be higher on the activity series than the element it can switch with in the compound. In the reaction between zinc and hydrogen sulfate, zinc, a cation, is higher on the activity series than hydrogen, a cation, so zinc switches with hydrogen to form the products H2 and ZnSO4. A cation can only switch places with a cation and an anion can only switch places with an anion. In order for a double replacement reaction to occur, like the reaction between copper (II) nitrate and sodium hydroxide, at least one of the products formed must be a solid, liquid, or gas. In the reaction between copper (II) nitrate and sodium hydroxide, the solid precipitate copper (II) hydroxide formed. The reaction occurred.

Reactions were written in their net ionic equation form because this only the elements/compounds that are directly involved in the chemical change are present. The ions floating around in the solution that are not involved in the chemical change (known as spectator ions) are taken out. This makes it easier for scientists to study what compounds are directly involved in the reaction and how they are breaking apart and forming.

The percent yield of copper was calculated in the calculations above. Percent yield calculates the percent of an amount of a substance gotten from an experiment out of the total amount that should have been gotten. The equation for percent yield is (actual yield/theoretical yield) X 100. When the actual yield is less than the theoretical yield, the percent is less than 100 percent. When the actual yield is more than the theoretical yield, the percent is greater than 100 percent. In both cases, errors and/or contaminants were made or present due to mistakes in the lab. Although it is impossible for the actual yield to equal the theoretical yield due to human error, it should be very close.

The main idea that allowed for this experiment to be conducted is the Law of Conservation of Mass. The Law of Conservation of Mass states that mass cannot be created or destroyed. The amount of copper wire used in the experiment was 2.030 grams. In the end, a group should not theoretically obtain less or more than the 2.030 grams of copper precipitate because copper’s mass cannot be created or destroyed. When less or more than is obtained, this law allows for the conclusion that contaminants were present or human error was made. This theorem allowed this experiment to take place because it is theoretically guaranteed to get the same mass of copper back that groups started with.

Sources of Error:

There are many sources of error in this lab. One source of error was that the scale on which the copper wire, evaporating dish, and evaporating dish with the copper in it was weighed on was not balanced correctly. With nothing on the scale, the scale read a negative number. This would have caused more than 2.030 grams of copper to be used in the lab and lower measurement readings for the evaporating dish and evaporating dish plus the copper if it was not accounted for. This, because it was accounted for, did not affect the group’s readings but could have affected other groups’ readings who did not account for the incorrect balance.

Another source of error in this lab was having to transfer the solution of copper (II) hydroxide precipitate and the aqueous sodium nitrate to a bigger beaker because the beaker that held the solution was too small for heating. In transferring the products to a bigger beaker, some of the precipitate stuck to the sides of the small beaker. It was not possible to get all of the blue precipitate out without using a lot of water, and this would have caused the solution to overflow when it was heated. Therefore, a small bit of the blue precipitate was left in the small beaker. This resulted in less copper (II) hydroxide to be broken down in the decomposition reaction. This, therefore, affected all of the reactions occurring after it because the amount of substance reacting should have been a little bit more than was present. Therefore, measurements were slightly too small. The final mass of the copper precipitate may have even weighed a little bit more than measured due to this error.

There is another source of error that affects the final mass of the copper. If not all of the zinc particles reacted with the cupper (II) sulfate or the added sulfuric acid, these particles would have added to the copper precipitate’s mass, causing a higher reading than the actual mass of the copper by itself. If not all of the water was evaporated during the steam bath, this would have further increased the final mass of the copper read from the scale. Water is very heavy, so even a little bit of extra water could have made a very big difference in the mass readings. As mentioned in the conclusion above, an ionic salt formed a crust on top of the copper precipitate. This added to the mass of the copper precipitate, making the reading higher than the actual mass of the copper was. The two possibilities for this ionic salt were sodium nitrate and zinc sulfate. These compounds could have remained in the solution throughout the experiment due to the inability to decant all of the liquid without losing some of the precipitate.

All of these contaminants caused the reading of the final mass of the copper to be too high. Rather than ending up with the initial 2.030 grams of copper, the group ended up with 13.103 grams of copper. The contaminants present with the copper in the evaporating dish during measurement caused not only the high readings, but also the high percent yield. Ending up with more than what the group started with caused a number greater than 100 percent. This is proof that copper was not the only thing present in the evaporating dish due to the Law of Conservation of Energy. One or many things added to the increased mass and, therefore, the extremely high percent yield.

Analysis Questions:

1. There are a few possibilities of why the reaction between copper and nitric acid in step 2 is placed on ice. One reason may be for safety. When the reaction occurs between copper and nitric acid, the solution gets hot and releases nitrogen dioxide gas. This is not healthy to breathe in. Therefore, by putting the beaker in an ice bath, any leftover nitrogen dioxide gas will condense due to the cold and, therefore, not be released and breathed in by the students. Another reason is that the solution may need to be kept cool for the second reaction. It is possible that the second reaction cannot take place if the solution temperature is too high. Therefore, an ice bath is used to cool the solution so the next compounds can be added and the reaction can take place.
2. In step 4, a double replacement reaction occurred. In step 7, a double replacement reaction occurred. In step 9, a single replacement and/or oxidation reduction reaction occurred.
3. Zn (s) + H2SO4 (aq) → ZnSO4 (aq) + H2 (g). An incomplete reaction would result in some unreacted zinc particles. The zinc particles are solids, so this would add to the mass of the evaporating dish when the copper precipitate was weighed. This would result in a higher mass reading than the actual mass reading would have been if all of the zinc had reacted.
4. When the group washed the CuO, the ions removed from the beaker were Na+ and NO3-.
5. After the group added the H2SO4, the copper was in its aqueous ion form: Cu2+.
6. When the group washed the precipitated copper, the ions removed from the beaker were Zn2+ and SO42-.