6. Stoichiometry and Limiting Reagent

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6. Stoichiometry and Limiting Reagent

Purpose:

> To practice using stoichiometry and identifying and calculating the limiting reagent by reacting copper(II) sulfate with iron, determining the limiting reagent, and observing the reaction for precipitates and changes and calculating the percent yield and writing formulas using stoichiometry.

Procedure:

1. Place about 7.00g of copper(II) sulfate in a beaker.
2. Add about 50mL of water to the beaker.
3. Arrange the beaker and stand.
4. Carefully heat and stir the mixture in the beaker. The solution should be hot but not boiling. After all the crystals have dissolved, remove the beaker from the heat.
5. Add about 2.00g of iron fillings slowly to the hot $CuSO_4$ solution while stirring. Record observations.
6. Allow the beaker to cool for 10-15 minutes.
7. Pour off(decant) the solution into a different beaker. Pouring the solution down a stirring rod is recommended. Make sure not to disturb the solid product.
8. Add a small amount of water(at least 10mL) to the copper and stir.
9. Let the copper settle to the bottom of the beaker and decant again.
10. Dry the copper and mass it.

Data:

Mass empty beaker w/ tape	**Mass $CuSO_4$**	**Mass Fe**	**Mass Beaker+Copper**
117.25g	7.00g	2.00g	119.42g

Observations:

> Water was exactly 50mL, all other measurements were exact.

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The tape on our beaker burned. Took about 1 minute 50 seconds to dissolve. Letting off steam. Seems to heat up more when adding the iron. Solution turned from blue to grey. Iron seemed to rust. Combined to form Fe_3O_3. Has an iron sort of smell. Precipitate settled to the bottom. Was a darker blue fluid with a red bubbling deposit on the bottom. Some filings stuck to the stirring rod and side of the beaker. Some of the tape burned off. After decanting, deposit was a wet, red powder. Decanted liquid was more of a teal color. There was a little bit of deposit that was decanted. Second decant was a more red color liquid. Definitely lost some of the precipitate. Third decant was more cloudy. Decanted liquid was a very clear, very light blue liquid with some precipitate. Final product was wet, red, some black, and powdery. After drying, it is a solid mass with a reddish-brown color. Very dry. Some iron left over. Some of the product was black.

Analysis:

Limiting Reactant	**Theoretical Yield**	**Percent Yield**
Iron	2.28g	95.2%

1. Iron is the limiting reactant. No more iron was left over, only copper.
   (2.00g Fe /55.85)*63.55=2.28g Cu
   (7.00g $CuSO_4$ /[63.55+32.06+4*16.00])*63.55=2.56g Cu
2. Iron was the limiting reactant so that there would be no iron left over with the copper. If copper(II) sulfate was the limiting reactant, there would be iron left in the copper, affecting the weight and calculation.

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3. Water was added to remove any underacted copper(II) sulfate, iron, and iron(II) sulfate. The solution was washed to isolate the copper.

4. The water added didn't matter if the measurement w for water was exact because it wasn't included in the reaction. Water was only used to wash the copper and help facilitate the reaction.

5. $Fe+CuCO_4->Cu+FeSO_4$ The formula for the iron-containing compound was $FeSO_4$. The observations support this as the color of the copper(II) sulfate solution got darker, so it is iron(II) that was used. So, it would be $Fe^{2+}+SO_4^{2-}->FeSO_4$, making the formula $FeSO_4$.

6. 95.2% Yield 119.42g-117.25g=2.17g (2.17/2.28)*100=95.2%

Conclusion:

The purpose of this lab was to practice identifying and calculating limiting reactants. We did this by combining copper(II) sulfate with iron filings and weighing the mass of the empty beaker, beaker with copper, and both reactants to use the mass to calculate the theoretical yield, actual yield, and percent yield. Through achieving this purpose, we were able to determine the limiting reactant and percent yield using the mass, and used observations to determine the charge of the iron used, when the reaction was complete, and what

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was left over after and what was left over was the limiting reactant. The limiting reactant turned out to be the iron, both through math and observations, as copper was all that was left after. All of the iron would have reacted to form iron(II) sulfate, leaving behind copper. The calculated theoretical yield was 2.28g of copper. We ended up with a final weight of 2.12g, making for a 95.2% yield. Some possible errors that may have affected our results are some copper(II) sulfate that was left unreacted, interacted iron filings stuck on the beaker and stirring rod, the tape on the beaker partially burned off reducing the mass, and accidentally decanting off some of the reactants or copper. If I were to to the lab again, I would use an amount of reactant close to what is required so that there are less unreacted reagents left over, I wouldn’t use tape, and I would make sure everything gets reacted fully, not stuck to the beaker or stirring rod. The percent yield tells me that some of the product was lost or never created. There was less copper left in the beaker than there could have been. Our methods were not thorough or careful enough to get perfect results and our results are only as good as the scale we mass it it and how complete our reaction was.