Post-lab KEY Quantitative Analysis Lab

Chemistry

Name:_____ Date:_____ Per._____

Purpose Statement:

The purpose of this experiment is to determine the coefficients for the balanced equation, identify the limiting/excess reagents, and to determine the percent yield of the reactions

Hypothesis:

When the mass of the products formed in a reaction are determined, then the percent yield of the reaction can be determined by expressing the mass of the actual to the mass of the theoretical as a percent.

Variables:

IV: Mass of limiting reagent (mass of copper (II) chloride)

DV: Mass of product formed (mass of copper)

Control: The theoretical yield of the product

Materials/Safety: $CuCl_2$, iron nail, beakers, wash bottle, petri dish, stirring rod, test-tube, tongs graduated cylinder. $CuCl_2$ is toxic, so avoid skin contact.

Summary of Procedure: In this experiment a known volume of copper (II) chloride will react with a sample of iron nails in a single replacement reaction. The copper product will be collected, dried, and weighed. The theoretical yield of copper will be predicted and the actual mass of copper will be measured. The percent yield of the reaction will be determined by finding the ratio of actual to theoretical yield formed, expressed as a percentage.

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Data Table for Quantitative Analysis Lab

	Trial 1
Color and appearance of nail	gray, solid
Color and appearance of copper (II) chloride	ocean blue solution
Molarity of copper (II) chloride (M)	1.0 M
Volume of copper (II) chloride (L)	0.0250 L
Mass of initial iron nails (g)	0.8034 g
Mass of empty beaker (g)	67.0523 g
Mass of beaker and iron product (g)	67.6739 g
Mass of leftover iron nails (g)	0.5154 g
Appearance of product, solution, and other observations	reddish-brown solid yellowish-greenish solution
Appearance of leftover nails and copper product	
Mole Ratio	
Percent Yield	
Percent Error	

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Analysis and Calculations: Show your work for all math questions, including significant figures and units. Answer all open-ended questions in complete sentences using the data from the lab to support your answer.

Theoretical Yield:

1. Write a word equation for the reaction.

copper (III) chloride (aq) + iron nails (s) → iron (II) chloride (aq) + copper (s)

2. Write a balanced chemical equation for the reaction and classify it.

1 $CuCl_2$ (aq) + 1 Fe (s) → 1 $FeCl_2$ (aq) + 1 Cu (s) Single Replacement

3. Calculate the number of moles of copper (II) chloride present in the solution.

moles = M x V

4. What is the maximum number of moles of copper that can be produced from the copper(II) chloride?

5. Calculate the number of moles of iron present in the nail?

moles = mass / 55.85

6. What is the maximum number of moles of copper that can be produced from the iron nail?

7. Which reagent is the limiting reagent? Explain

Copper (II) chloride is the limiting reagent because it produces the least amount of product and is used up first.

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8. Which reagent is the excess reagent? Explain

   Iron is the excess because it produces the greatest amount of product and there is still some left over.

9. What is the maximum number of grams of copper that can **theoretically** be produced from the limiting reagent?

   mass = moles x 63.55

10. How much excess (grams and moles) is left over?

Actual Yield:

1. How many grams of copper was **actually** produced?

   mass Cu = (mass beaker and product) - (mass empty beaker)

2. How many moles of copper were **actually** produced?

   moles Cu = mass Cu / 63.55

3. How many grams of iron **actually** reacted?

   mass Fe = (mass of nail before - mass of nail after)

4. How many moles of iron **actually** reacted?

   moles Fe = mass Fe / 55.85

5. Determine your percent yield?

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percent yield = (actual yield / theoretical yield) x 100

6. What is the mole ratio of copper to iron?

   mole Cu / mole Fe

7. Does your mole ratio agree with your balanced equation? Explain your answer.

8. Calculate the percent error in your value for the mole ratio. Your teacher will give you the accepted value.

   percent error = [(experimental value - accepted value) / accepted] x 100

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Post-lab Questions: Use a separate sheet of paper to answer the questions below. Show your work for all math questions, including significant figures and units. Answer all open-ended questions in complete sentences using the data from the lab to support your answer.

1. What happened to the iron metal that was consumed in this reaction?

   The iron metal went into solution (blueish-green) with the chloride ions.

2. Did all of the copper (II) chloride react in this experiment? Show all calculations and explain your reasoning?

   No, all of the copper (II) chloride did not react because the blue color (Cu ions) was still present and it was the excess reagent. The nail was the limiting reagent but was left over because it did not stay in the reaction long enough to completely react. The copper (II) chloride could make …..…moles of copper and the iron nail could make …..…moles of copper. As a result, the copper (II) chloride will be used up by the nail.

3. Copper could be lost in this experiment during the washing and decanting steps. How would this affect the iron: copper mole ratio? Explain.

   When Cu is lost during the washing and decanting steps, the number of moles of copper will decrease which means the iron to copper mole ratio will be less than 1:1.

4. The percent yield reflects the actual amount of product formed as a percentage of the maximum that might have been obtained. Discuss your results here. Should your results be accepted? Explain your reasoning.

   In this experiment, the percent yield of copper was determined to be 68.02%. This percent yield is acceptable/not acceptable because the value is below/above the accepted value for this class. The results for this experiment should/should not be accepted because a percent yield of 68.02% is within/below the range of the accepted value of 80%.

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5. Describe how your percent yield would be affected by each of the following experimental errors listed below:
    a. The final product was not completely dry before weighing.

        The percent yield would be calculated to be too high because some of the water was present in the product causing the actual yield to be higher than it should have been.

    b. The nail was dirty and not polished.

        The percent yield would be calculated to be too high because the dirt and contamination would add to the product formed and the actual yield would be too high.

    c. The concentration of the copper (II) chloride was 1.0 M but you used 0.50 M in your theoretical calculations.

        The percent yield would be too high because the theoretical yield value that was calculated was lower than it should have been because a greater concentration was used. As a result the actual yield is going to be higher than it should be because more product will be formed because of the greater concentration.

    d. The nail was improperly rinsed and some of the product is left behind on the nail.

        The percent yield will be too low because some of the product was not accounted for and that causes the actual yield to be smaller than it should be because of the loss of product.

6. Compare your result to one of your classmates.
    a. Which trial had a better percent yield? Explain using data.

        My trial/ My classmates percent yield was….. and my trial/ my classmates trial was…… In comparing the two trials, me/my classmate had a better percent yield.

    b. Propose a reasonable explanation for your results.

        In discussing the results with my classmate, I can say that I/they had a better percent

    c. Were the masses of iron and copper the same in all experiments?

        No/Yes they were/were not because……..

    d. Were the mole ratios the same?

        Yes/No, they were/ were not because……

    e. Does the mole ratio of a substance in a chemical equation depend on the amounts of reactants used?

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No, the mole ratio only depends on the balanced chemical equation.

yield because…

7. What other factors (besides loss due to transfer) might account for any error in your percent yield? Explain specifically why you didn't get 100% yield of your product.

   One factor that may account for errors in our percent yield is the reaction may not have gone to completion and the maximum amount of product was not formed. A second factor that may account for errors in percent yield is competing side reactions from contamination (on the nail or the beaker) that may produce additional gas products that can be lost to the atmosphere.

8. How do those errors affect your results?

   An incomplete reaction will affect my percent yield in that it would be calculated ……. because……

   A competing side reaction will affect my percent yield in that it would be calculated ……. because……

9. What are some improvements you can make to this experiment to improve your results? Be specific to the lab.

   A change that can be made to prevent an incomplete reaction is……..this would improve my results because…..

   A change that can be made to prevent competing side reactions is……this would improve my results because…..

10. How will those improvements affect your accuracy (percent yield)?

    The improvements to the experiment will affect my percent yield by causing the value to increase because……