

## Investigation: Stoichiometry

For this investigation, you will create and share (with editing permission) a Google Doc formal write-up ([cgaupp@ga.hiltoncsd.net](mailto:cgaupp@ga.hiltoncsd.net)). All research questions given in this document must be addressed. You will be assessed on your ability to follow directions as well as your knowledge of stoichiometry and your evaluation of the investigation.

### Formatting:

Proper formatting serves two purposes. First, it allows the reader to find and evaluate all pertinent information quickly and easily. Second, it is a reflection of the author's organizational skills and attention to detail. ALWAYS WRITE IN THE 3RD PERSON!!

- 1 inch margins (left, right, top, bottom) - this is the default
- 12 point font (the default font of Google Docs is sufficient)
- Double spaced - easier to read and add comments if printed
- Page numbers on the bottom of each page

The following must be addressed in your report:

- The balanced chemical equation for the reaction of iron and copper (II) sulfate.  
*INTRODUCTION*
- Show your calculations used to determine how much iron and copper (II) sulfate you needed to prepare the given amount of copper metal. These should include mole:mole ratio calculations based upon your balanced chemical equation. (Use Insert Equation function here.) *CALCULATIONS*
- Compare your actual yield with your theoretical yield. What was your % Yield? Show the calculation. ( $\% \text{Yield} = \text{Actual Yield} / \text{Theoretical Yield} \times 100$ ) *CALCULATIONS*
- Using the observations you made during the investigation and the calculations you performed in determining the amounts of reactants you needed to carry out the reaction, evaluate the theoretical mole:mole ratio (based on the balanced equation) compared to your results. Did the stoichiometry you performed accurately predict how much copper you produced? What might be the reason for any difference? (Think random vs. systematic error.)  
*CONCLUSIONS / EVALUATION*
- Discuss how stoichiometry can be used to determine the amounts of products made as well as which reagent will limit the amount of product made. In your investigation, which reactant was limiting? Which was in excess and by how much? (Show calculations.) *CALCULATIONS*

## Investigation of the Production of Copper Metal Through Stoichiometry

*You and Your Partner's Name*

### **Introduction:**

What is the purpose of the lab? What chemical techniques are you using (i.e. stoichiometry, single replacement reactions). How is stoichiometry used to predict (hypothesize) how much of a product can be made? Remember that a hypothesis need not be an 'if...then' statement. It merely needs to be a prediction you can test. In this case, you're determining if stoichiometry can be use to accurately predict how much stuff can be made.

### **Materials:**

List all of the chemicals you used (chemical name AND formula - sodium chloride (NaCl)) and the laboratory equipment you used. This should be a **bulleted** list and should be single spaced. Include safety equipment used as well.

### ***THIS IS A SAMPLE LIST OF MATERIALS!!!!***

- Sodium chloride (NaCl)
- Potassium phosphate ( $K_3PO_4$ )
- hot plate
- 50 mL beaker
- glass stirring rod

**Methodology:**

This should be a detailed set of instructions. Anyone should be able to repeat your experiment.

This should be in **your own words**, not copied from the lab sheet you were given. Write this in paragraph form (NO bulleted lists!) A sample is given below:

*To a 100 mL beaker was added iron filings (2.56g, 0.54 moles) and distilled water (50 mL). The green solution was stirred and heated on a hot plate. To the iron and water mixture was added gold (1.45g, 0.05 moles). The mixture was heated to 110 degrees Celsius for 20 minutes after which time it was removed from the hot plate and allowed to cool. The resulting solid was decanted from the liquid and dried in an oven overnight. A silver-colored solid (3.42g, 0.25 moles, 82%) was recovered.*

**Data:**

All data and observations need to be reported here. Raw data should be in table format with clearly labeled HEADINGS and UNITS, with uncertainties. Your observations can be included as a paragraph after the data table.

Item Massed	Mass (g)
Empty beaker	
Copper (II) sulfate crystals	
Iron (Fe) filings	
Beaker and dry product	
Dry product alone	

### **Calculations / Analysis:**

Your calculations (using the Equation Editor) should be done here. Show your calculations for how you determined how much of each reactant you needed to use to produce the copper. Determine the limiting reagent of your investigation. Determine which reactant was in excess. Calculate the %Yield. You should also consider uncertainty measurements here. What was the uncertainty in the balance? In the graduated cylinder? These calculations should be clearly labeled and easy to follow.

### **Conclusions / Evaluation:**

Restate the purpose of the investigation and your prediction. Make concluding remarks with respect to your results. Did you get the results you were expecting? Was stoichiometry a valid method to predict the amount of a product that can be produced in a chemical reaction? Why or why not? Did stoichiometry (and limiting reagent) help explain some of your observations and potential results? Discuss any types of error you encountered (not human error). Consider both random and systematic error. Explain these. Yes and no answers are not in depth enough.

Finally, evaluate the laboratory investigation. What went well? What could you have improved? How could you reduce the amount of error you observed? (If you didn't have any error, think about how you may have achieved this.) This should be a thoughtful reflection about the investigation.

## Laboratory Assessment Criteria

**Analysis:** This criterion assesses the extent to which the student's report provides evidence that the student has selected, recorded, processed and **interpreted** the data in ways that are relevant to the research question and can support a conclusion. This includes calculations.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1-2	<p>The report includes <b>insufficient relevant</b> raw data to support a valid conclusion to the research question.</p> <p>Some <b>basic</b> data processing is carried out but is either too <b>inaccurate or too insufficient to lead to a valid</b> conclusion.</p> <p>The report shows evidence of little consideration of the impact of measurement uncertainty on the analysis.</p> <p>The processed data is incorrectly or insufficiently interpreted so that the conclusion is invalid or very incomplete.</p>
3-4	<p>The report includes relevant but incomplete quantitative and qualitative raw data that could support a simple or partially valid conclusion to the research question.</p> <p>Appropriate and sufficient data processing is carried out that could lead to a broadly valid conclusion but there are significant inaccuracies and inconsistencies in the processing.</p> <p>The report shows evidence of some consideration of the impact of measurement uncertainty on the analysis.</p> <p>The processed data is interpreted so that a broadly valid but incomplete or limited conclusion to the research question can be deduced.</p>
5-6	<p>The report includes sufficient relevant quantitative and qualitative raw data that could support a detailed and valid conclusion to the research question.</p> <p>Appropriate and sufficient data processing is carried out with <b>the accuracy</b> required to enable a conclusion to the research question to be drawn that is fully <b>consistent</b> with the experimental data.</p> <p>The report shows evidence of full and appropriate consideration of the impact of measurement uncertainty on the analysis.</p> <p>The processed data is correctly interpreted so that a completely valid and detailed conclusion to the research question can be deduced.</p>

**Evaluation:** This criterion assesses the extent to which the student's report provides evidence of evaluation of the investigation and the results with regard to the research question and the accepted scientific context.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1-2	<p>A conclusion is <b>outlined</b> which is not relevant to the research question or is not supported by the data presented.</p> <p>The conclusion makes superficial comparison to the accepted scientific context.</p> <p>Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are outlined but are restricted to an account of <b>the practical</b> or <b>procedural issues</b> faced.</p> <p>The student has <b>outlined</b> very few realistic and relevant suggestions for the improvement and extension of the investigation.</p>
3-4	<p>A conclusion is <b>described</b> which is relevant to the research question and supported by the data presented.</p> <p>A conclusion is described which makes some relevant comparison to the accepted scientific context.</p> <p>Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are described and provide evidence of some awareness of the <b>methodological issues*</b> involved in establishing the conclusion.</p> <p>The student has <b>described</b> some realistic and relevant suggestions for the improvement and extension of the investigation.</p>
5-6	<p>A detailed conclusion is <b>described and justified</b> which is entirely relevant to the research question and fully supported by the data presented.</p> <p>A conclusion is correctly <b>described and justified</b> through relevant comparison to the accepted scientific context.</p> <p>Strengths and weaknesses of the investigation, such as limitations of the data and sources of error, are discussed and provide evidence of a clear understanding of the <b>methodological issues</b> involved in establishing the conclusion.</p> <p>The student has <b>discussed</b> realistic and relevant suggestions for the improvement and extension of the investigation.</p>

**Communication:** This criterion assesses whether the investigation is presented and reported in a way that supports effective communication of the focus, process and outcomes.

Mark	Descriptor
0	The student's report does not reach a standard described by the descriptors below.
1-2	<p><b>The presentation of the investigation is unclear, making it difficult to understand the focus, process and outcomes.</b></p> <p>The report is not well structured and is unclear: the necessary information on focus, process and outcomes is missing or is presented in an incoherent or disorganized way.</p> <p>The understanding of the focus, process and outcomes of the investigation is obscured by the presence of inappropriate or irrelevant information.</p> <p>There are many errors in the use of subject-specific terminology and conventions*.</p>
3-4	<p><b>The presentation of the investigation is clear. Any errors do not hamper understanding of the focus, process and outcomes.</b></p> <p>The report is well structured and clear: the necessary information on focus, process and outcomes is present and presented in a coherent way.</p> <p>The report is relevant and concise thereby facilitating a ready understanding of the focus, process and outcomes of the investigation.</p> <p>The use of subject-specific terminology and conventions is appropriate and correct. Any errors do not hamper understanding.</p>

\*For example, incorrect/missing labelling of graphs, tables, images; use of units, decimal places. For issues of referencing and citations, refer to the 'Academic Honesty' section in the guide.