LAB [25 pts] Name_________________________________

Precipitation of Copper(II) Phosphate Lab partner(s)_________________________

Period_______ Date_________

Introduction: When doing a reaction, it is important to know how much of each reactant is needed to form a particular amount of product. In this lab, you will be doing the following precipitation reaction:

$3\ CuSO_4\ (aq)$	+	$2\ Na_3PO_4\ (aq)$	→	$Cu_3(PO_4)_2\ (s)$	+	$3\ Na_2SO_4\ (aq)$
copper(II) sulfate		sodium phosphate		copper(II) phosphate		sodium sulfate
(clear blue soln)		*(clear colorless soln)*		*(blue solid)*		*(colorless solution)*

You will compare how much product you actually isolated with how much you should have gotten (according to mass-mass calculations). In addition, this lab will introduce you to some basic laboratory techniques such as filtration, washing and drying.

Purpose: The purpose of the lab is to successfully carry out the above precipitation reaction, successfully isolate the products and obtain a good yield of both products.

Pre-lab question: Do the pre-lab question that is on the write-up sheet.

Procedure:

1) In a weighing boat, mass out close to 0.50 g of **blue copper(II) sulfate hydrate**. Carefully transfer this blue solid into a clean 150 ml **beaker**.
2) Mass out a clean, dry 125 mL **Erlenmeyer flask**. Record the exact value.
3) In a weighing boat, mass out the amount of white sodium phosphate hydrate needed. (See your pre-lab question & add about *0.03g-0.05 g to your calculated mass.)* Put **white solid in the flask**. Record mass.
4) **Completely dissolve** each of the solids by adding about **15 ml of distilled water** to each solid. Carefully swirl the solutions. Make sure that each solid has dissolved.
5) Slowly **pour** the colorless sodium phosphate solution that is in the flask into the blue copper(II) sulfate solution that is in the beaker. Rinse the last traces of sodium phosphate from the flask into the beaker with **two small amounts** of distilled water (use water bottle). Carefully swirl the resulting mixture (in beaker) for a good three minutes to make sure substances have reacted fully.
6) Obtain a piece a **filter paper** and write your names on it ***with pencil***. Mass it out and record in table.
7) Set up ring stand with ring and funnel. Fold the filter paper, fit the filter paper into the funnel and moisten the paper with some distilled water.
8) Put the flask under the funnel. Carefully pour the mixture from the beaker into the filter paper. *Don't let it overflow!!! (Hint: Swirl and pour quickly-- so that you get the maximum amount of solid out.)*
9) Try to remove as much of the blue solid from the beaker as possible by spraying the beaker with some distilled water and pouring into filter. (It helps if you *tilt* your beaker above the filter as you spray.)
10) Wash the solid in filter paper by spraying with water bottle *(Don't overdo it! 5 seconds is long enough.)*
11) When the filtering is complete, carefully remove the filter paper from the funnel. Carefully unfold it and lay it flat to dry overnight. *(You will mass it out dry, tomorrow.)*
12) Remove the flask and boil the filtrate (the solution in the flask) on a hot plate. It may take as long as 20 to 30 minutes to boil away all of the water, so take turns keeping watch. Remove flask from the hot plate immediately when all the liquid has boiled away.

Day 2:

13) Mass out the dry filter paper with blue copper(II) phosphate product. Record mass.
14) Mass out your flask with the white sodium sulfate product in it. Record mass.

Data Chart: Fill in the data chart on the write-up sheet as you do the procedure.

Calculations: Do all calculations on the write-up sheet.

Conclusions: [11 pts] *You must answer in complete sentences.* ***This must be TYPED!!***

a) [2 pts]As you know, mass should be conserved in a chemical reaction. However, sometimes there are experimental errors that cause some gain or loss of mass. Did you lose or gain mass overall? Give two possible experimental errors that could account for this overall change in mass.

Note: *An experimental error cannot be an error due to measuring or calculating wrong. Also, the error cannot be due to inaccurate or imprecise measuring equipment.*

b) [1 pts] Based on your relative experimental mole values (See Calculations #1), determine which reactant should have been the excess reactant and explain your reasoning.

c) What was the color of your filtrate (the solution that went through your filter and into the flask)? Based on your color of the filtrate, which reactant was actually in excess?

d) [4 pts] State the % yield of your blue copper(II) phosphate. Was your yield too high or too low? No matter how good your yield, discuss two possible systematic errors--one which could account for a high yield of copper(II) phosphate and one which could account for a low yield.

e) [4 pts] State the % yield of your white sodium sulfate. Was your yield too high or too low? No matter how good your yield, discuss two possible systematic errors--one which could account for high or low yield of sodium sulfate and one which could account for a low yield.

Post Lab Questions: [9 pts] *(Answer in COMPLETE sentences.* ***These must be TYPED!!****)*

1) [2 pts] In this lab, you were able to separate the copper(II) phosphate (blue product) from the sodium sulfate (white product). Describe the basic process of isolating the products and explain how their solubility differences allowed for isolation. *(In other words, how was copper(II) phosphate collected? How was sodium sulfate collected? Explain why by discussing solubilities.)*

2) [2 pts] In this experiment, you tried to add almost the exact mole ratios needed to allow both reactants to completely react.

   a) How would the purity of your two products have been affected if you had used excess copper(II) sulfate? *Which product would be contaminated—blue copper(II) phosphate or white sodium sulfate? Why would this product be contaminated (solubility!!)? Would you be able to see this contamination (colors?)?*

   b) How would the purity of your two products have been affected if you had used excess Na_3PO_4? *Which product would be contaminated—blue copper(II) phosphate or white sodium sulfate? Why would this product be contaminated (solubility)? Would you be able to see this contamination (colors)?*

3) This experiment should have convinced you that mass must be conserved in a chemical reaction, but moles do not have to be conserved. *(In other words, the mass of the reactants must equal the mass of the products. However, the total moles of reactants do NOT have to equal the total moles of the products).*

   a) [1 pt] Explain why mass must be conserved in a chemical reaction. *(You must explain by discussing atoms.)*

   b) [2 pts] Without mentioning mass or molar mass, explain why it is not necessary for moles to be conserved in a chemical reaction.

   HINT: In this lab, if you started with 5 moles of reactants, you would produce 4 moles of products (see the balanced equation). Explain why this is possible by discussing atoms and/or molecules. Remember—"moles" is just a measure of the number of particles. To make things simpler, try to explain how 2 moles could be changed into 1 mole. Alternatively, try to explain how 1 mole could be changed into 2 moles.

LAB-Write-up sheet [25 pts]
Precipitation of Copper(II) Phosphate

Name________________________________
Lab partner(s)________________________
Period_______ Date_________

3 $CuSO_4$ (aq)	+	**2 Na_3PO_4 (aq)**	→	**$Cu_3(PO_4)_2$ (s)**	+	**3 Na_2SO_4 (aq)**
copper(II) sulfate		sodium phosphate		copper(II) phosphate		sodium sulfate
(clear blue soln)		*(clear colorless soln)*		*(blue solid)*		*(colorless solution)*

Prelab question: [1 pt] How many grams of solid Na_3PO_4 hydrate are needed to fully react 0.50 g of solid copper(II) sulfate hydrate?

**Hydrates are solids that have some water stuck within the crystal, but the solid still looks "dry". Thus, to calculate molar masses of hydrates, the mass due to the added water must be included. The "•" indicates the number of H_2O molecules added. *Note: once dissolved in H_2O, this water mixes with the solution and is not included in the reaction. First calculate the molar masses of the reactants:*

MM of $CuSO_4 \cdot 5\ H_2O$ (hydrate) =

MM of $Na_3PO_4 \cdot 12\ H_2O$ (hydrate) =

Mass $Na_3PO_4 \cdot 12\ H_2O$ =

$$0.50\ g\ CuSO_4 \cdot 5\ H_2O \times \underline{\hspace{3cm}} \times \underline{\hspace{3cm}} \times \underline{\hspace{3cm}} =$$

DATA: Record all data here. Record to nearest 0.01 g. Show ALL UNITS!!!

Day 1 Data (Reactants)		Day 2 data (dry products)	
	Mass (g)		**Mass (g)**
copper(II) sulfate hydrate (blue)		blue copper(II) phosphate + filter paper	
sodium phosphate hydrate (white)		copper(II) phosphate (dry blue solid)	
Dry Erlenmeyer flask			
Filter paper		sodium sulfate in flask	
		sodium sulfate (dry white solid)	

What is the color of your filtrate (the solution that goes through the filter)? ________________________

Calculations: [6 pts]

1) Once you have started filtering, fill in the part of the chart concerning the reactants. On Day 2, after collecting dry products, complete the chart by filling in the parts concerning the products.

	Reactants		Products	
	copper(II) sulfate hydrate (blue) $CuSO_4 \cdot 5\ H_2O$	sodium phosphate hydrate (white) $Na_3PO_4 \cdot 12\ H_2O$	copper(II) phosphate (dry blue solid) **$Cu_3(PO_4)_2$**	sodium sulfate (dry white solid) **Na_2SO_4**
Experimental mass (g)				
Molar Mass (g/mol)				
Experimental moles				
Relative experimental mole values with $CuSO_4$ = 1 mole	1.00 mole			
Relative experimental mole values with $CuSO_4$ = 3 moles	3.00 moles			

2) In any reaction, the limiting reactant is the reactant that is completely used up. The excess reactant is the reactant that has some excess amount of it leftover. Based on your experimental mole ratios of your reactants, which reactant is the limiting reactant and which is the excess reactant?

The limiting reactant is ______________________________

The excess reactant is ______________________________

3) Calculate the **theoretical yield of copper(II) phosphate (blue product)**. *(Hint: Start with the mass of your limiting reactant and convert to the mass of copper(II) phosphate that should be produced.)*

4) Calculate your **percent yield of copper(II) phosphate (blue product).** (Wait to do this on Day 2.)

$$\% \text{ yield} = \frac{\text{experimental yield (g)}}{\text{theoretical yield (g)}} \times 100\% =$$

5) **Calculate the theoretical yield of sodium sulfate (white product)**. *(Hint: Start with the mass of your limiting reactant and convert to the mass of sodium sulfate that should be produced.)*

6) Calculate your **percent yield of sodium sulfate (white product).** (Wait to do this on Day 2.)

$$\% \text{ yield} = \frac{\text{experimental yield (g)}}{\text{theoretical yield (g)}} \times 100\% =$$

7) In any reaction, mass should be conserved. Thus, the mass of the reactants should equal the mass of the products. However, in this lab, there is one complication due to the fact that the reactants are hydrates. Since all the water is evaporated away in the products, we must "subtract out" the mass of water in the hydrates before comparing with the mass of the products. Work through the following steps to see if mass was conserved in this experiment.

a) How many grams of water are in the sample of copper(II) sulfate hydrate that you used?

$$\text{g } CuSO_4 \text{ hydrate} \times \frac{1 \text{ mol } CuSO_4 \text{ hydrate}}{\_\_\_\_\_\_ \text{ g } CuSO_4 \text{ hydrate}} \times \frac{\_\_ \text{ mol water}}{1 \text{ mol } CuSO_4 \text{ hydrate}} \times \frac{\_\_\_\_\_\_ \text{ g water}}{1 \text{ mol water}} =$$

b) How many grams of water are in the sample of sodium phosphate hydrate that you used?

$$\text{g } Na_3PO_4 \text{ hydrate} \times \frac{1 \text{ mol } Na_3PO_4 \text{ hydrate}}{\_\_\_\_\_\_ \text{ g } Na_3PO_4 \text{ hydrate}} \times \frac{\_\_ \text{ mol water}}{1 \text{ mol } Na_3PO_4 \text{ hydrate}} \times \frac{\_\_\_\_\_\_ \text{ g water}}{1 \text{ mol water}} =$$

c) Now do simple subtraction to get the mass of anhydrous reactants (mass without water):

Mass of anhydrous copper(II) sulfate = ____

Mass of anhydrous sodium phosphate ____

d) Compare the sum of the masses of the anhydrous reactants to the sum of the masses of the products.

Total mass of anhydrous reactants = ______________ **Mass lost/gained during reaction = _________**

Total mass of dry products = ________________ **Did you lose or gain mass?** _____________