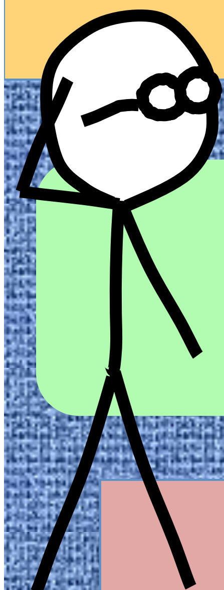
Experiment 4
17 September 2019
Synthesis of Copper(II) Oxalate

Alternative titles:

A. The Monster Anion Lab
B. Anions of Unusual Size (AUS)
C. Go Blue!

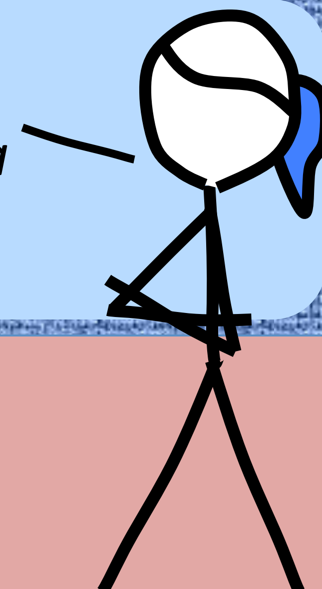
Eye on the prize!

Objectives: To use reaction stoichiometry to prepare a pure substance and to determine percent yield.



So, what's happening today?

We are being real chemists and doing a chemical reaction!

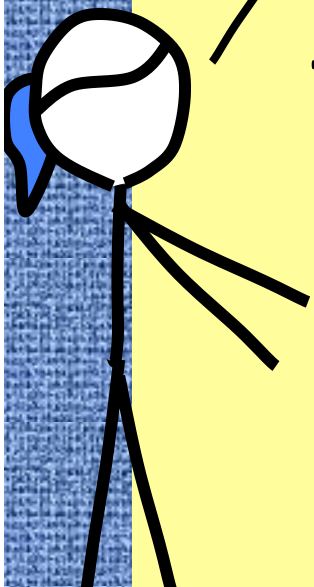


Overview:

1. The Reaction
2. Thinking in moles
3. Limiting reagent and percent yield
4. Procedure for today
5. Your lab report and
6. Blue Crystal Beauty Pageant

And I'm judging the Blue Crystal Beauty pageant!

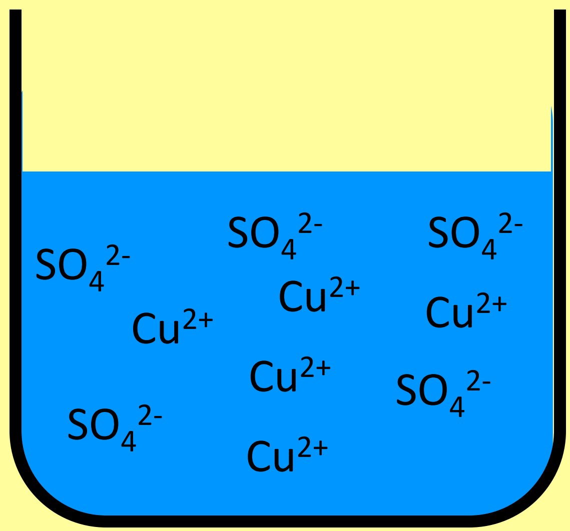
1. The Reaction – The Reactants



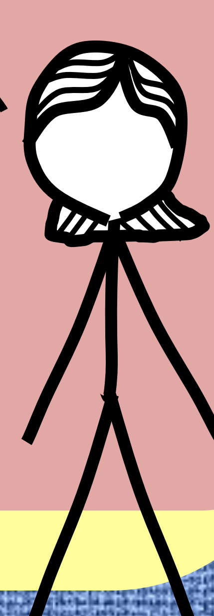
One of the reactants today is copper(II) sulfate pentahydrate. It is a beautiful blue crystalline solid. Here is a representation of copper(II) sulfate in solution. The five waters of hydration become part of the solution when it dissolves.

The solid: $CuSO_4 \cdot 5\ H_2O(s)$

In solution: $CuSO_4(aq)$

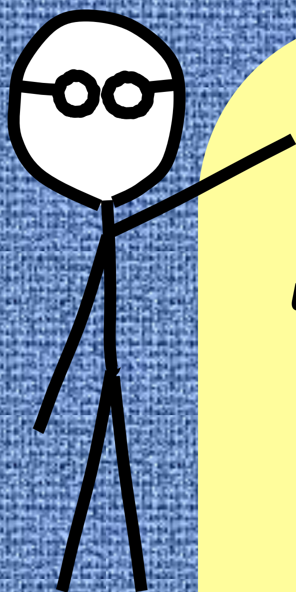


Rule! All ionics that dissolve, dissociate 100% into ions in solution.

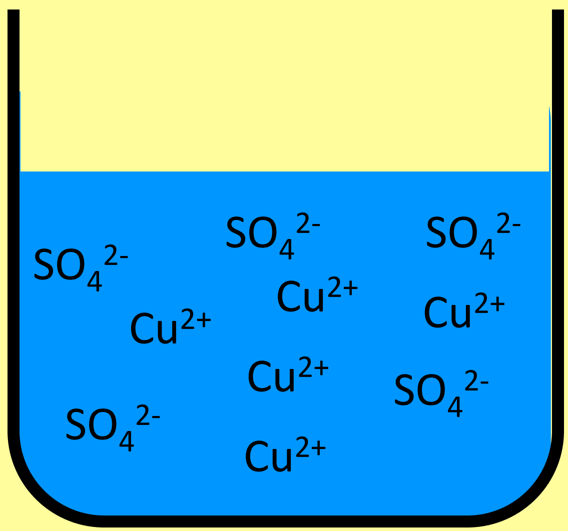


Info for Introduction

1. The Reaction – The Reactants



Sooo, the rule "All ionics that dissolve, dissociate 100% into ions in solution" means that when we write $CuSO_4(aq)$, we understand that it is really $Cu^{2+}(aq)$ and $SO_4^{2-}(aq)$ ions swimming around like in the picture. It is just a little easier to write it the first way, so people do.

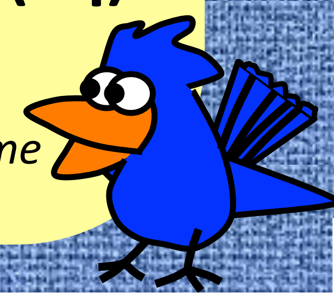


$$\mathbf{CuSO_4(aq)}$$

is the same as

$$\mathbf{Cu^{2+}(aq) + SO_4^{2-}(aq)}$$

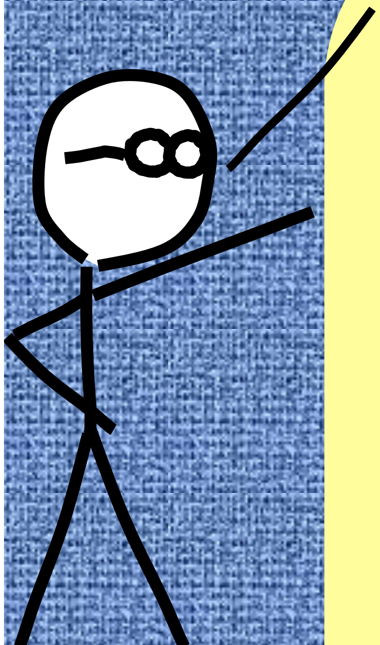
Swimming? Really?



It's the same thing!

Info for Introduction

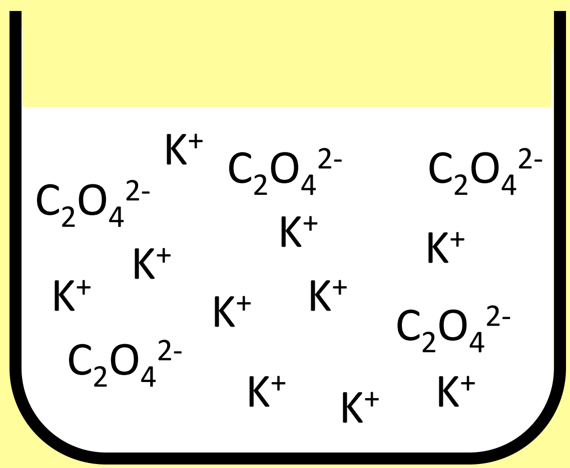
1. The Reaction – The Reactants



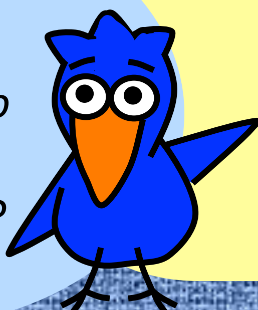
The other reactant is potassium oxalate monohydrate. It is a white crystalline solid. All potassium salts dissolve in water forming ions in solution. Here is a representation of this solution. The one water of hydration becomes part of the solution.

The solid: $K_2C_2O_4 \cdot H_2O(s)$

In solution: $K_2C_2O_4(aq)$



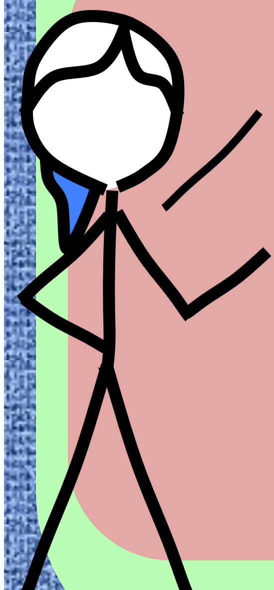
Why don't we break up the oxalate ion into carbon and oxygen atoms?



*Again – **all ionics that dissolve, dissociate 100% into ions in solution**. And you already know what happens to the water of hydration. Right…?*

1. The Reaction

$$CuSO_4(aq) + 2\ K_2C_2O_4(aq) \rightarrow K_2Cu(C_2O_4)_2(H_2O)_2(aq) + 2\ K_2SO_4(aq)$$



This is the reaction. One mole of copper(II) sulfate is reacted with two moles of potassium oxalate to form the product, $K_2Cu(C_2O_4)_2(H_2O)_2$ (which is named with nomenclature rules that are more advanced and awkward to use).

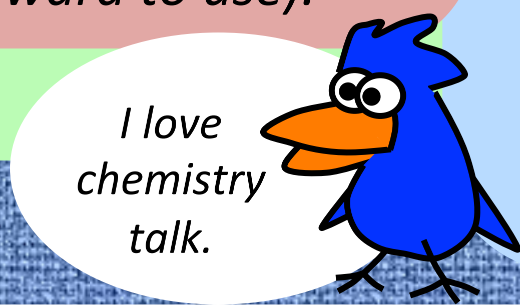
$K_2Cu(C_2O_4)_2(H_2O)_2(aq)$

*exists as **$K^+(aq)$***

***cations** and*

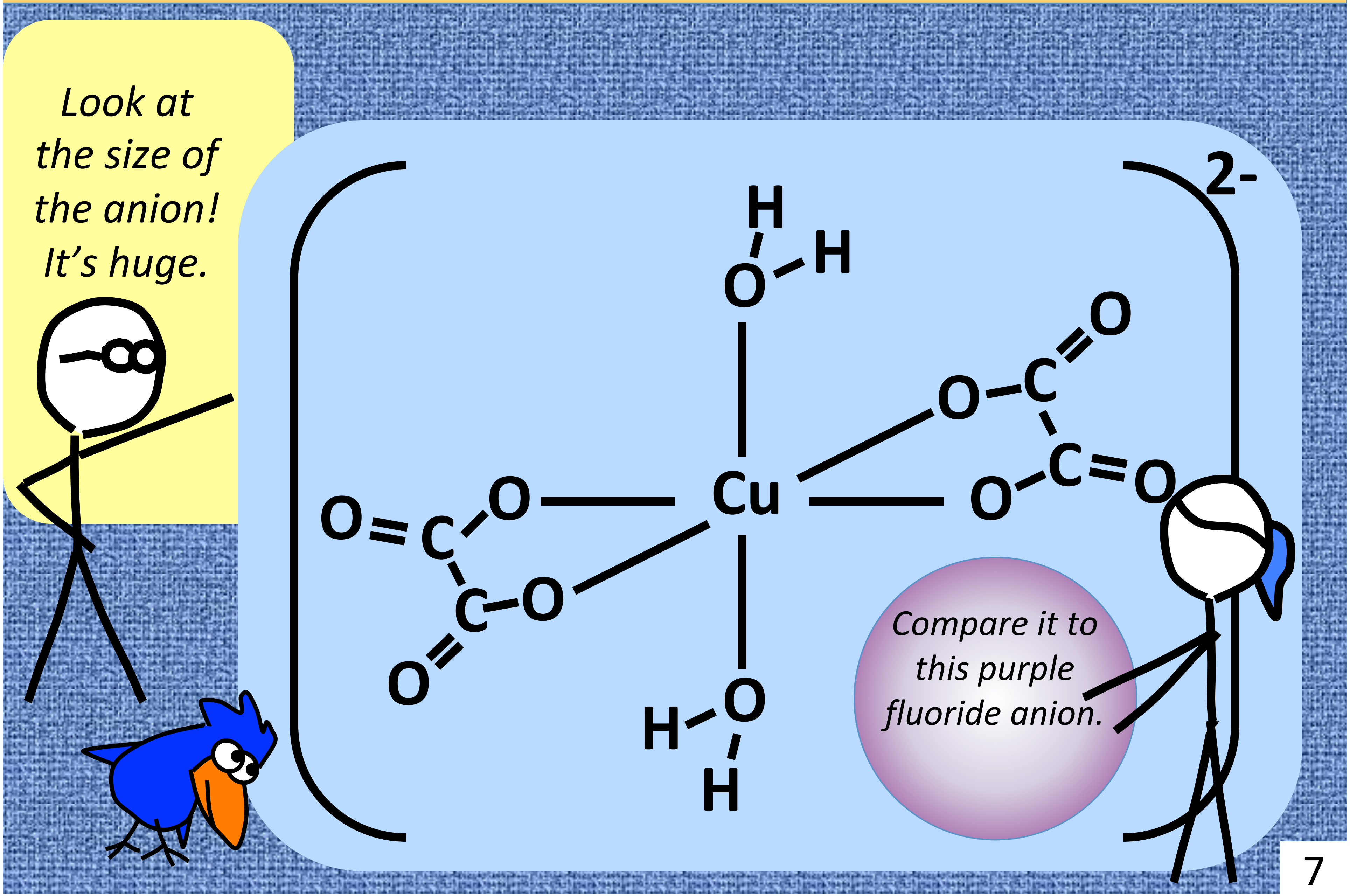
$Cu(C_2O_4)_2(H_2O)_2^{2-}(aq)$

***anions** in solution.*



Info for Introduction

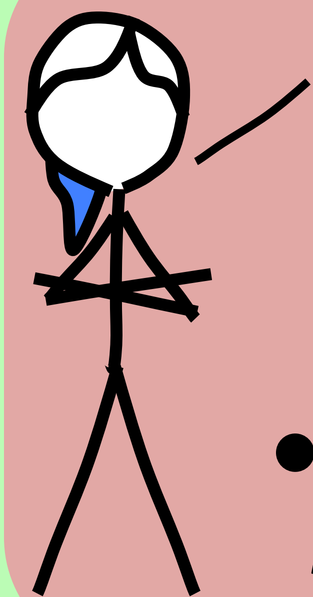
1. The Reaction



2. Thinking in Moles

$$CuSO_4 \cdot 5\,H_2O(s) \quad + \quad 2\,K_2C_2O_4 \cdot H_2O(s) \quad \rightarrow$$

3.0 g   **5.0 g**



The lab manual says to use 3.0 g $CuSO_4 \cdot 5\,H_2O$

and 5.0 g $K_2C_2O_4 \cdot H_2O$

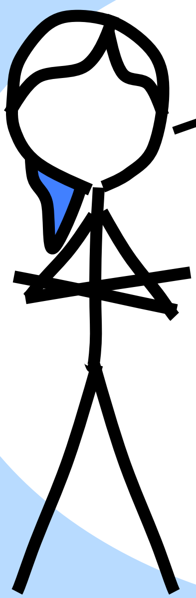
Work like this requires precision! We must use the analytical balances! Measure out approximately 3.0 g and 5.0 g, but do not waste time making it 3.000 g! Values should be close – for example 3.012 or 2.989 g.

Info for calculations

2. Thinking in Moles

$$CuSO_4 \cdot 5\,H_2O(s) \quad + \quad 2\,K_2C_2O_4 \cdot H_2O(s) \quad \rightarrow$$

3.0 g   5.0 g



So suppose we measured out 2.989 g $CuSO_4 \cdot 5\,H_2O$ and 4.991 g $K_2C_2O_4 \cdot H_2O$.

Each has 4 sig figs

We then convert both from mass to moles.

We are going to need molar masses!

Yes! Molar masses!

Info for calculations

2. Thinking in Moles

$$CuSO_4 \cdot 5\,H_2O(s) \quad + \quad 2\,K_2C_2O_4 \cdot H_2O(s) \quad \rightarrow$$

3.0 g   **5.0 g**

$CuSO_4 \cdot 5H_2O$ can be written as $CuSO_9H_{10}$

1 x 63.546 g/mol for Cu
1 x 32.06 g/mol for S
9 x 15.999 g/mol for O
10 x 1.008 g/mol for H

= 249.677 g/mol

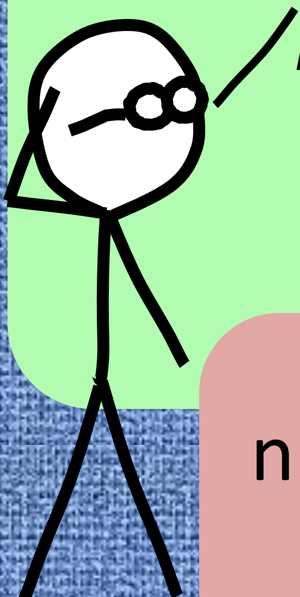
Sulfur is only known to the hundredths place, and so it must be with the answer – MM = 249.68 g/mol

You can do the MM for $K_2C_2O_4 \cdot H_2O$ the same way…

Pssst! It's 184.24 g/mol

Info for calculations

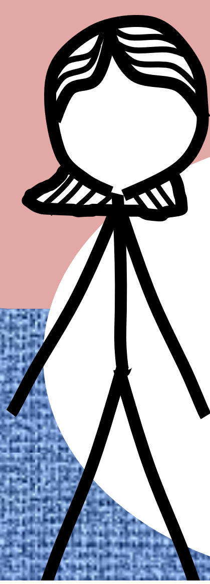
2. Thinking in Moles



Now we convert mass to moles! Let's start with the 2.989 g $CuSO_4 \cdot 5\ H_2O$

The sig fig rule for dividing tells us the answer can only have 4 sig figs. But we keep all of these for now for calculations in order to prevent propagation of errors due to rounding.

$$n = \frac{2.989\ \text{g}}{} \bigg| \frac{\text{mol}}{249.68\ \text{g}} = 0.0119713\ \text{mol}$$



Now you convert 4.991 g $K_2C_2O_4 \cdot H_2O$ to moles…

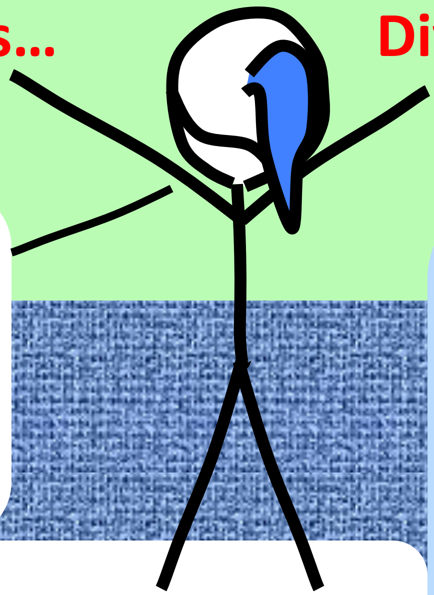
The numbers in gray can't stay in our final answer – but we keep them for now. This usually gives better results.

Info for calculations

3. Limiting reagent and percent yield

$$CuSO_4 \cdot 5\,H_2O(s) \quad + \quad 2\,K_2C_2O_4 \cdot H_2O(s) \quad \rightarrow$$

2.989 g	**4.991 g**
0.0119713 mol	**0.0270897 mol**
Divided by 1 gives…	**Divided by 2 gives…**
0.01197	**0.01354**

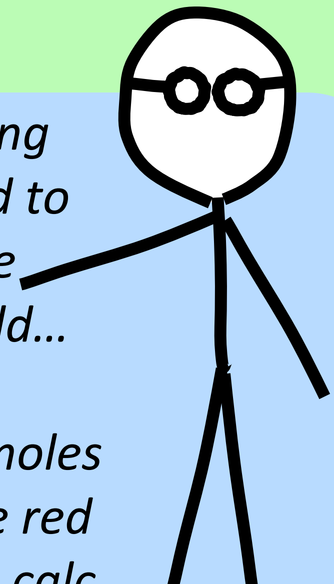


If I divide the moles by the coefficients, the smallest number tells me which is the limiting reagent

so $CuSO_4 \cdot 5\,H_2O$
Is the limiting reagent.

And the limiting reagent is used to calculate the theoretical yield…

Use the actual moles in black, not the red numbers for this calc.



Info for calculations

3. Limiting reagent and percent yield

$$\mathbf{CuSO_4\cdot 5\,H_2O(s) + 2\,K_2C_2O_4\cdot H_2O(s) \rightarrow K_2Cu(C_2O_4)_2(H_2O)_2 + ...}$$

0.0119713 mol **Theoretical yield**

$$n_{\text{Theor Yld}} = \frac{0.0119713\text{ mol } CuSO_4\cdot 5\,H_2O}{} \left|\, \frac{1\text{ mol } K_2Cu(C_2O_4)_2(H_2O)_2}{1\text{ mol } CuSO_4\cdot 5\,H_2O}\right.$$

$$n_{\text{Theor Yld}} = 0.0119713\text{ mol } K_2Cu(C_2O_4)_2(H_2O)_2$$

3. Limiting reagent and percent yield

$$CuSO_4 \cdot 5\,H_2O(s) + 2\,K_2C_2O_4 \cdot H_2O(s) \rightarrow K_2Cu(C_2O_4)_2(H_2O)_2 + \ldots$$

0.0119713 mol **T. Y. = 0.0119713 mol**

If we knew the molar mass of $K_2Cu(C_2O_4)_2(H_2O)_2$, we could convert theoretical yield from moles into grams

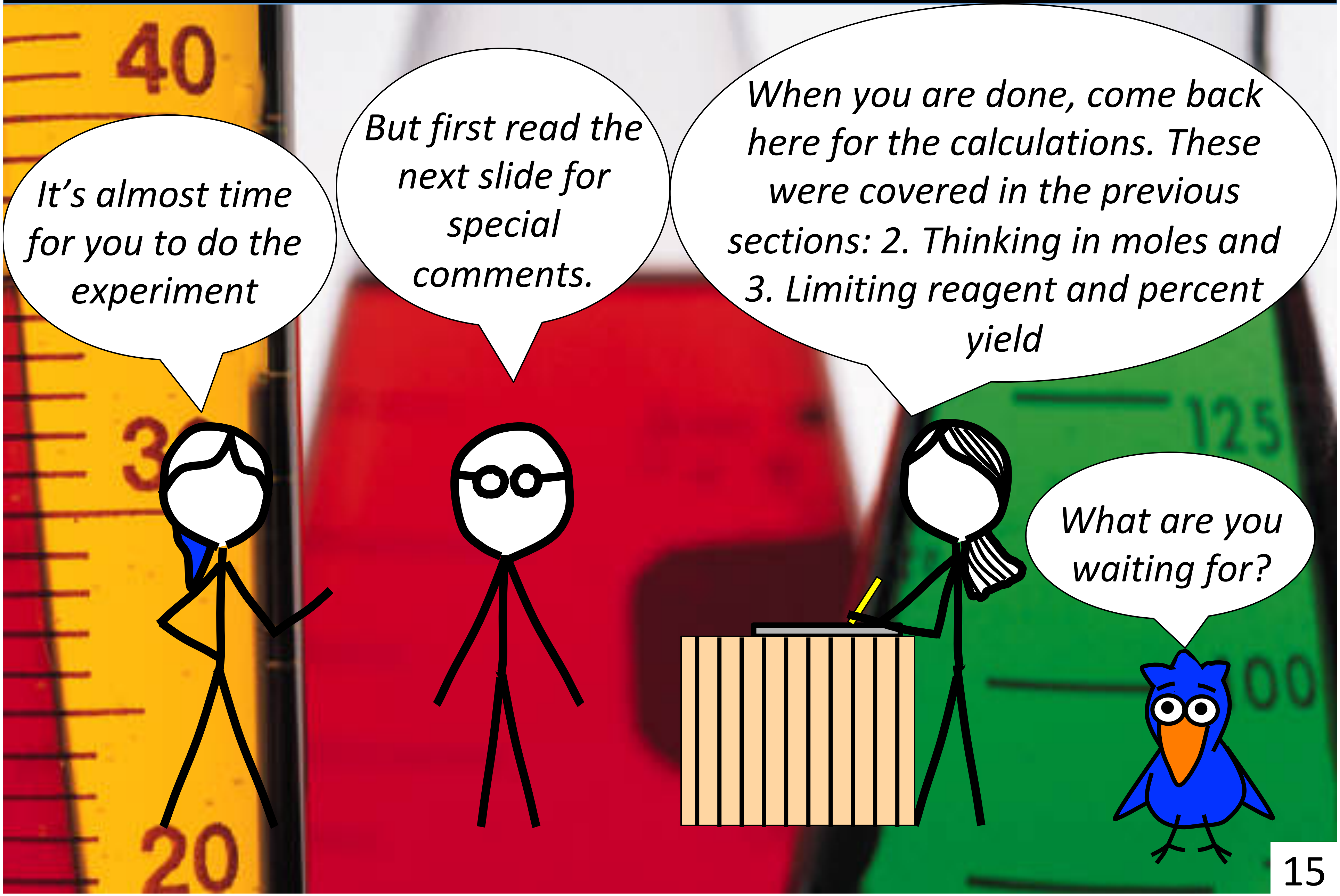
Our final answer for theoretical yield is 0.01197 mol

Then we calculate percent yield with this simple formula…

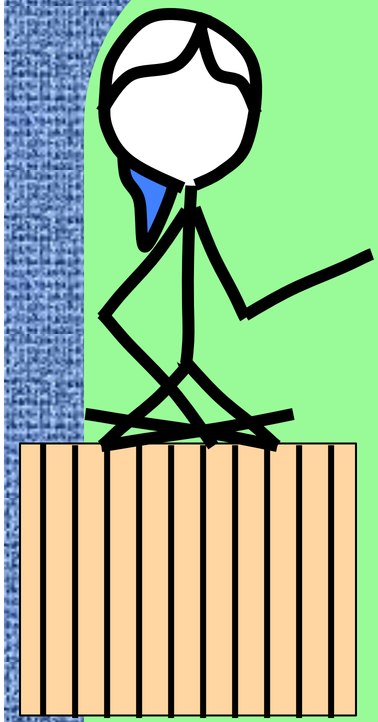
$$\text{Percent Yield} = 100\% \times \frac{\text{Actual Yield in g}}{\text{Theoretical Yield in g}}$$

Info for calculations

4. Procedure for today



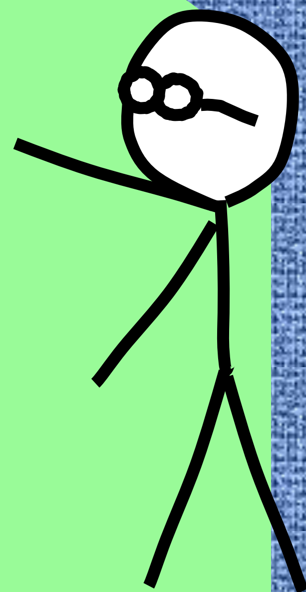
4. Procedure comments



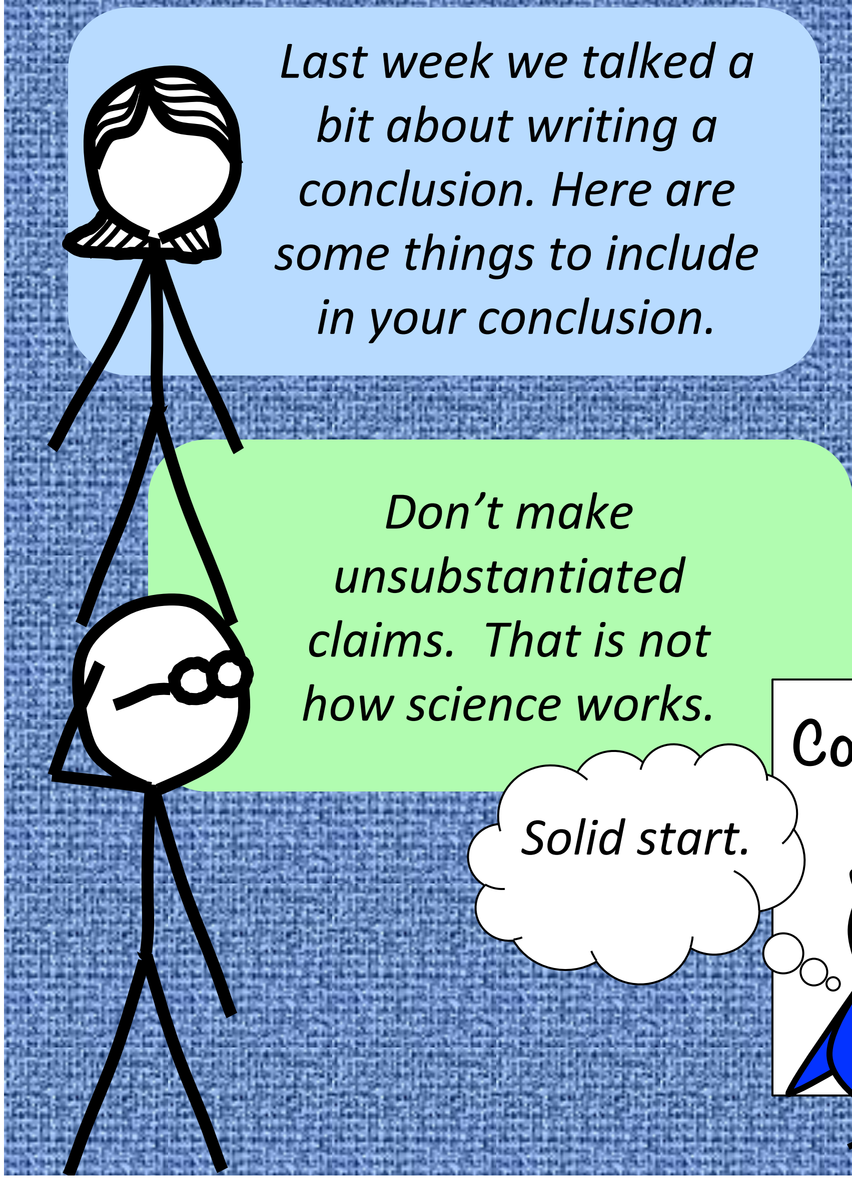
I. *Wear your safety glasses today. Dress for a mess.*

II. *Use an analytical balance for measuring masses today. Report masses to the third place past the decimal. Do NOT strive for exact masses. For example 4.991 g is good. Or 5.021 is good. But 5.000 g meant you wasted time and made people wait. Not good.*

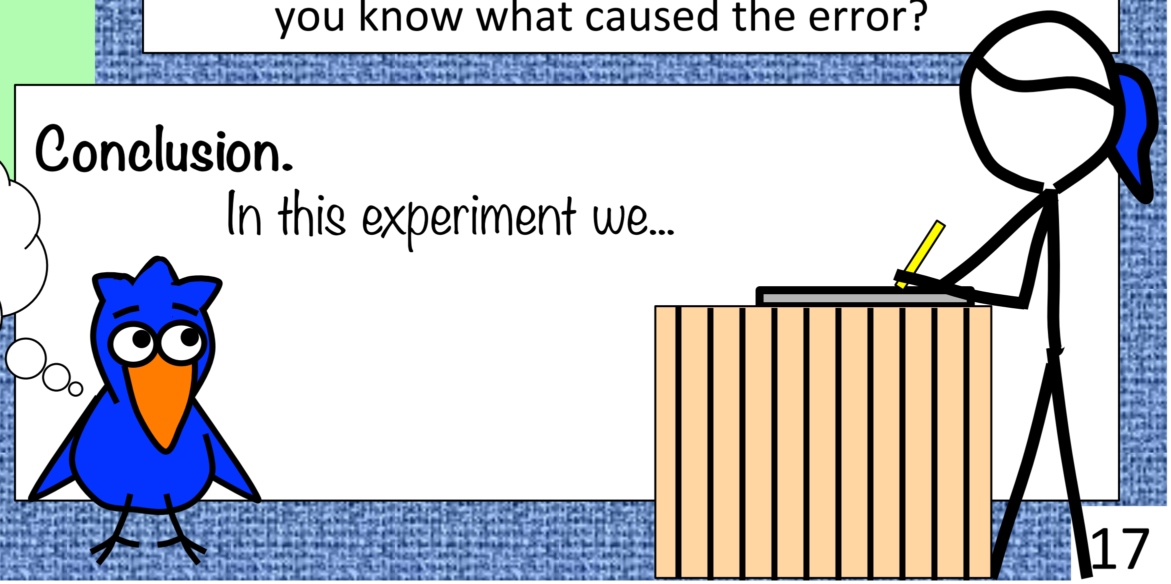
III. *You should turn in your crystals in a weighing boat. Make a label with your names and lab station and section (either DD or HH)*



5. Your lab report



1. In a sentence or two, describe what you did in lab today and what lab techniques you used. Some of this was also in your introduction, but after the experiment, you know more specifics about the techniques you used.
2. Describe your results and what you think they mean. Be as specific as possible. This will be several sentences.
3. Calculate percent error if appropriate. Do you know what caused the error?



5. Your lab report and
6. The Blue Crystal Beauty Pageant.

① First, the cover page with TA initials.

② Next, the trimmed copy pages from your lab notebook stapled together.

③ Enter ***on-line data*** before you leave lab. Your calculations will be checked as well as correct use of units and significant figures. You can do most of this while your crystals are drying in the oven. *Late submissions are not graded – see the syllabus.*

④ Turned in lab report today or ***before*** the start of class tomorrow. *Late labs may not be graded – see the syllabus.*

Stick people inspired by xkcd cartoons by Randall Munroe (www.xkcd.com)

Chem Lab with the Stick People and Bird *was created and produced by Dr. Bruce Mattson, Creighton Chemistry. Enjoy it and share it if you wish.*