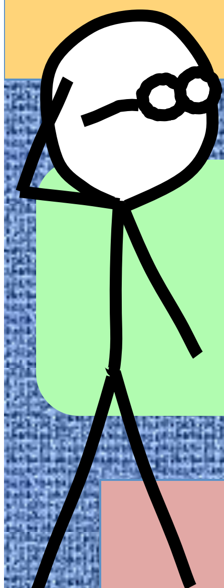
# Experiment 4
# 18 September 2018
# Synthesis of Copper(II) Oxalate

## Alternative titles:

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

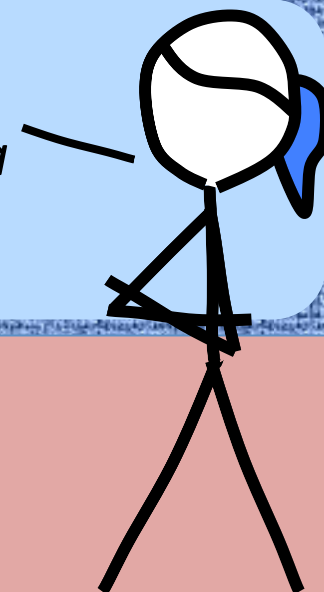

*Eye on the prize!*

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



*So, what's happening today?*

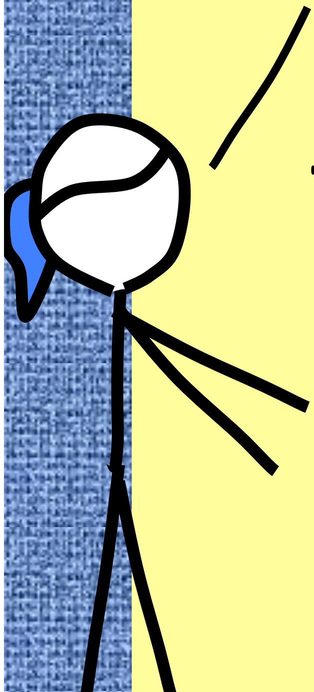
*We are being real chemists and doing a chemical reaction!*



**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

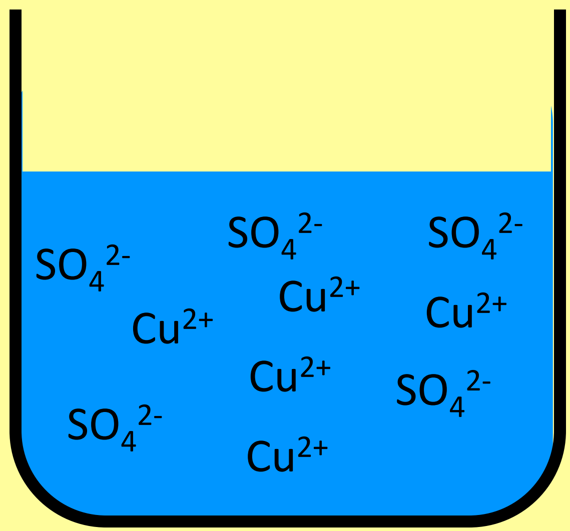
# 1. The Reaction – The Reactants



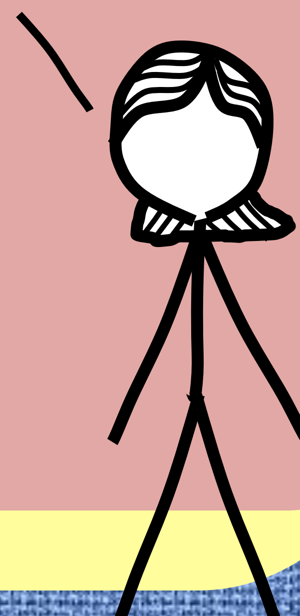
*One of the reactants today is copper(II) sulfate pentahydrate. It is a beautiful blue crystalline solid. Here is a representation of copper(II) sulfate in solution. The five waters of hydration become part of the solution when it dissolves.*

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

**In solution: $CuSO_4(aq)$**

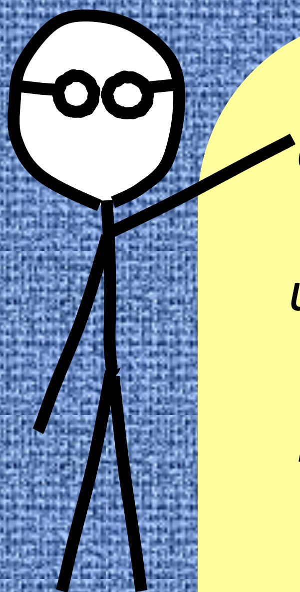



*Rule! All ionics that dissolve, dissociate 100% into ions in solution.*

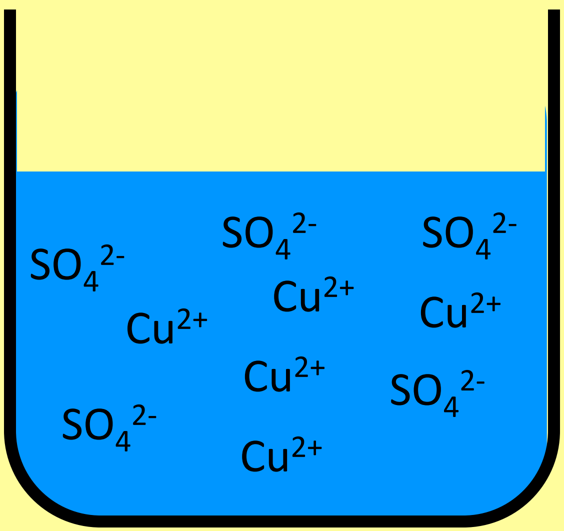


**Info for Introduction**

# 1. The Reaction – The Reactants



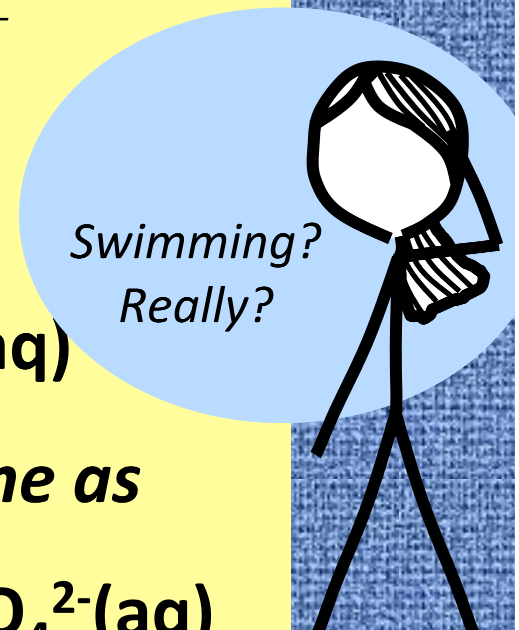
*Sooo, the rule "All ionics that dissolve, dissociate 100% into ions in solution" means that when we write $CuSO_4(aq)$, we understand that it is really $Cu^{2+}(aq)$ and $SO_4^{2-}(aq)$ ions swimming around like in the picture. It is just a little easier to write it the first way, so people do.*

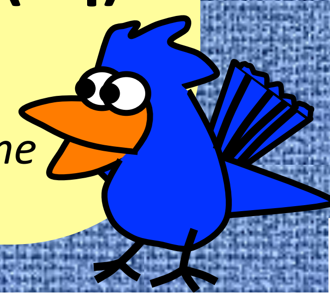



**$CuSO_4(aq)$**

***is the same as***

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

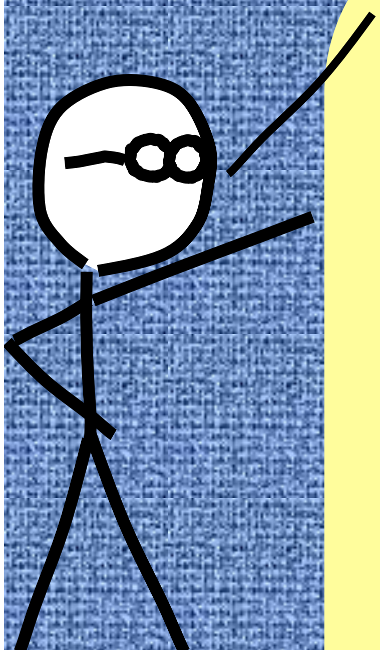


*It's the same thing!*

**Info for Introduction**

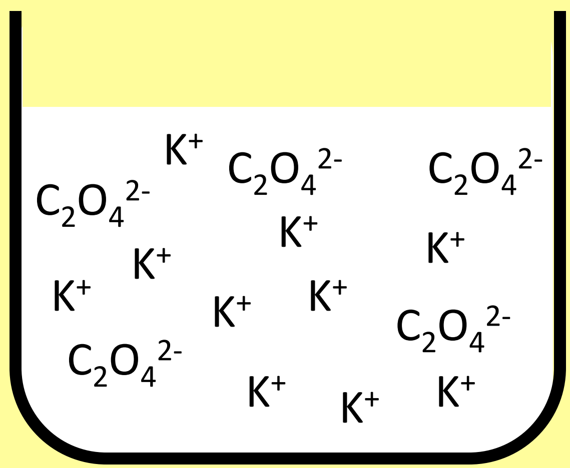
# 1. The Reaction – The Reactants

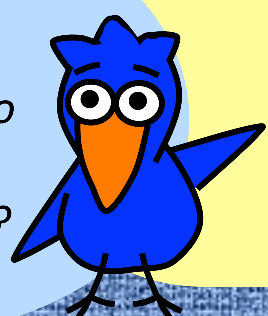


*The other reactant is potassium oxalate monohydrate. It is a white crystalline solid. All potassium salts dissolve in water forming ions in solution. Here is a representation of this solution. The one water of hydration becomes part of the solution.*

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

**In solution: $K_2C_2O_4(aq)$**



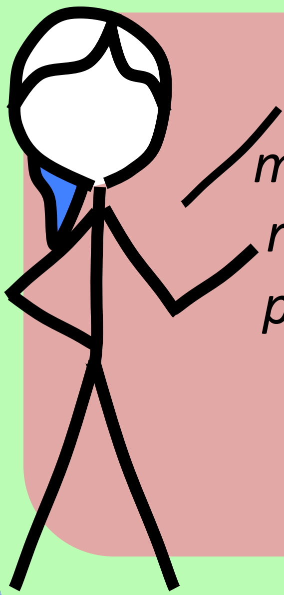
*Why don't we break up the oxalate ion into carbon and oxygen atoms?*

*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 potassium copper(II) oxalate and potassium sulfate.*

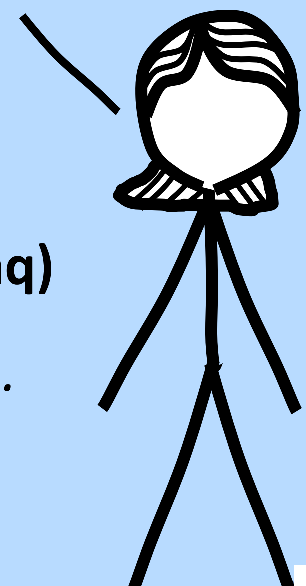
$K_2Cu(C_2O_4)_2(H_2O)_2(aq)$

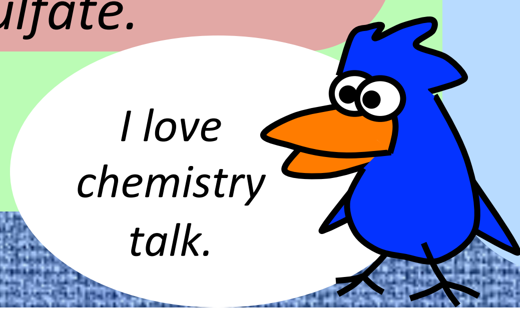
*exists as **$K^+$(aq)***

***cations** and*

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

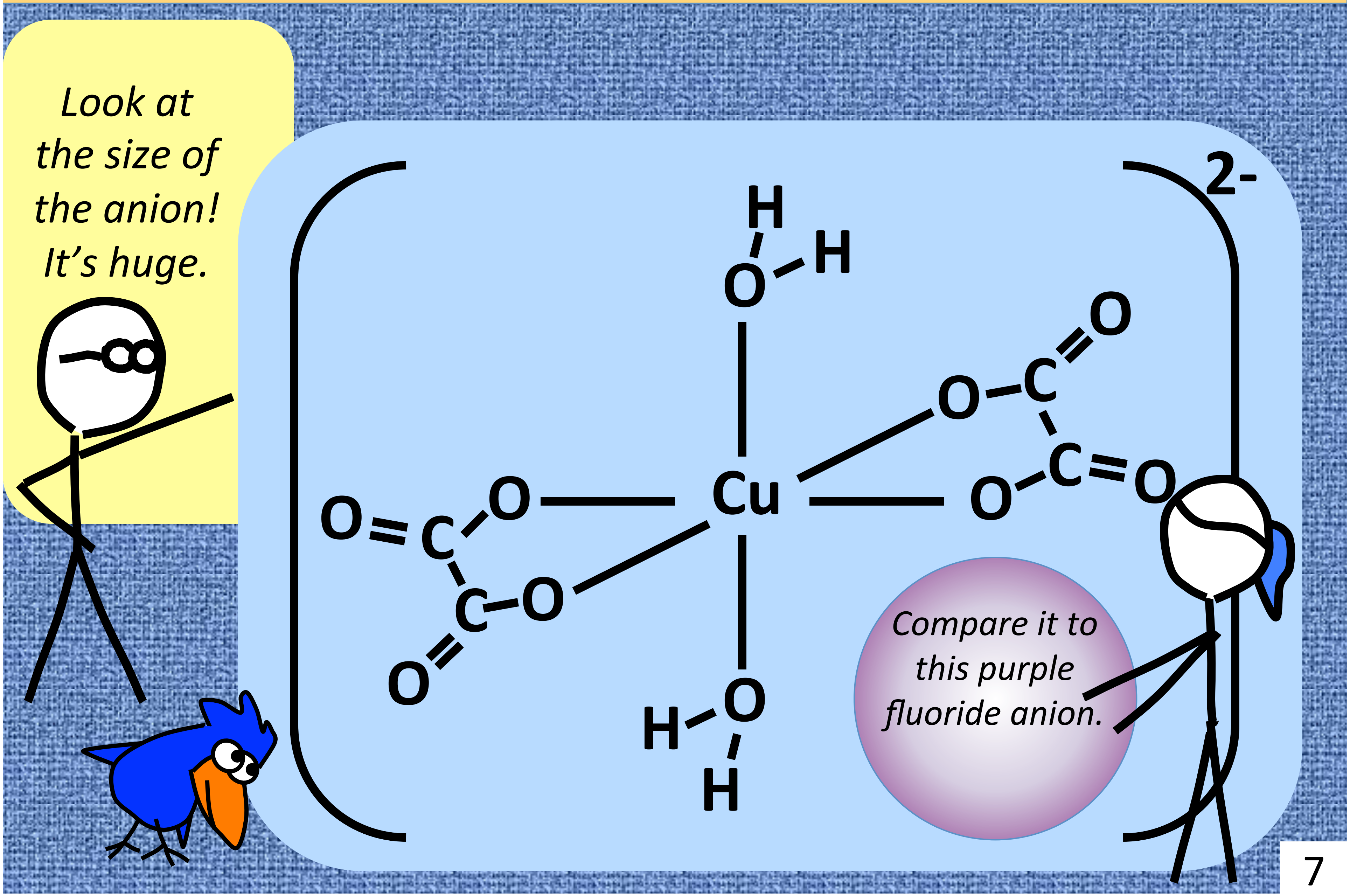
***anions** in solution.*






**Info for Introduction**

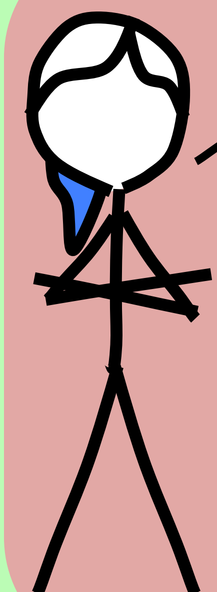
# 1. The Reaction



# 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 $K_2C_2O_4 \cdot H_2O$*

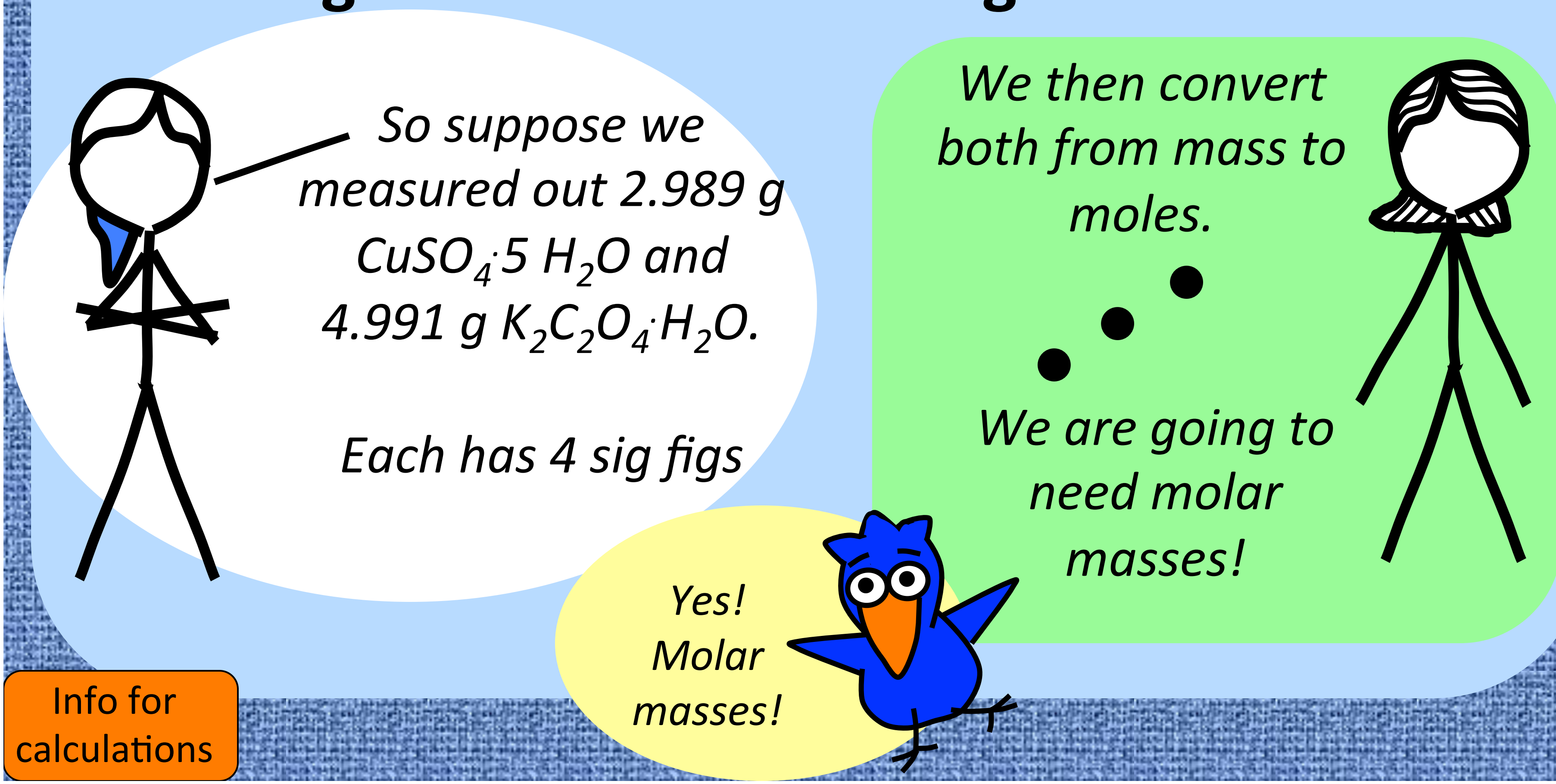
*Work like this requires precision! We must use the analytical balances! Measure out approximately 3.0 g and 5.0 g, but do not waste time making it 3.000 g! Values should be close – for example 3.012 or 2.989 g.*

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**




Info for calculations

# 2. Thinking in Moles

**$CuSO_4 \cdot 5\,H_2O(s)$ + $2\,K_2C_2O_4 \cdot H_2O(s)$ →**

**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.*

$$n = \frac{2.989\ \text{g}}{} \left|\, \frac{\text{mol}}{249.68\ \text{g}} \right. = 0.0119713\ \text{mol}$$

*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

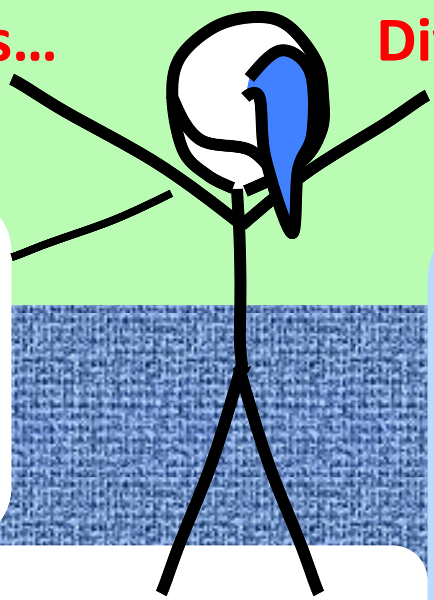
$CuSO_4 \cdot 5\,H_2O(s)$ + $2\,K_2C_2O_4 \cdot H_2O(s)$ →

2.989 g      4.991 g

0.0119713 mol      0.0270897 mol

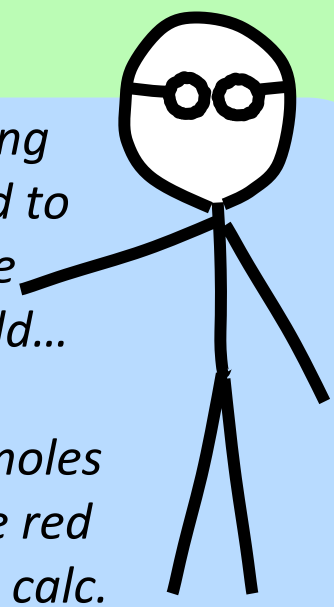
Divided by 1 gives… 0.01197

Divided by 2 gives… 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

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

**0.0119713 mol** **Theoretical yield**

*The stoichiometry between $CuSO_4 \cdot 5\,H_2O$, the limiting reagent, and the product, $K_2Cu(C_2O_4)_2(H_2O)_2$ is 1 : 1 so the theoretical yield of product is the same as the moles of reactant.*

*Obviously.*

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

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

# 3. Limiting reagent and percent yield

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

**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*

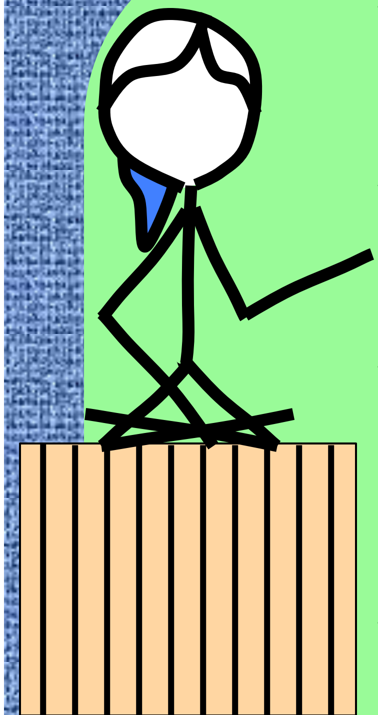
*Our final answer for theoretical yield is 0.01197 mol*

*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 (pg. 24)



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

II. *Use an analytical balance for measuring masses today.*

III. *Don't bother with the thermometers – just look for the appearance of steam – then it's hot enough.*

IV. *In Part B, Crystallization, Step 4, use a syringe as a source of vacuum for vacuum filtration.*

V. *You should turn in your crystals in a weighing boat. Make a label with your names and lab station and section (either CC or EE)*

# 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.
4. Turned in lab report today or ***before*** the start of class tomorrow.



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