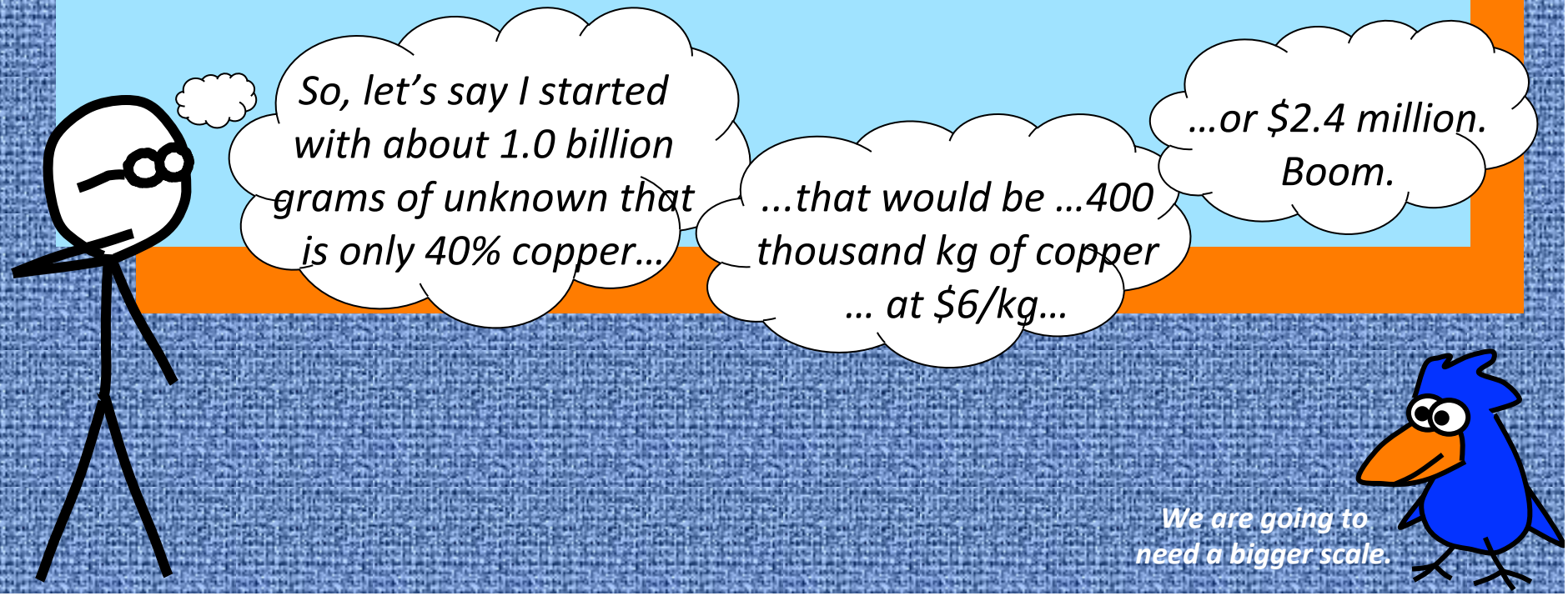
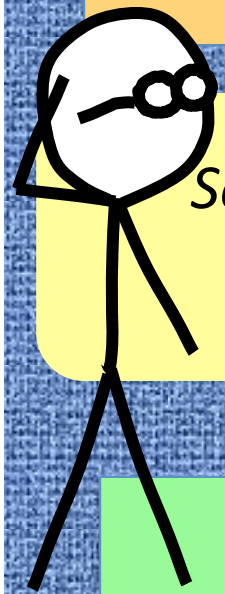
Experiment 4
21 September 2017
Percent Copper and Molar Mass of a Copper Compound

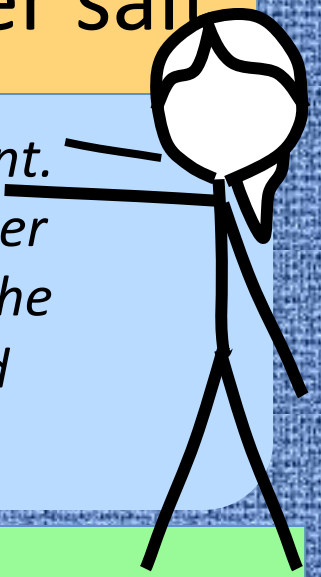


Objectives: To determine percent copper and molar mass of an unknown copper salt



So, we are making copper today?

Well, yeah... but that's not the point. We will figure out how much copper is in an unknown copper salt and the molar mass of the unknown. And that's pretty awesome!

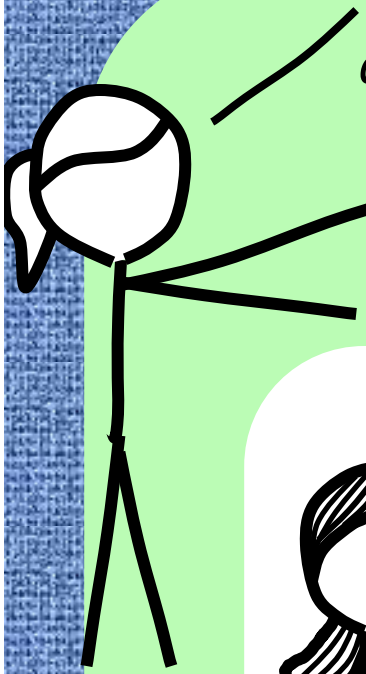


Overview:

1. Overview formulas, molar mass and % Cu
2. Procedure Overview
3. Calculations
4. Procedure
5. Your lab report

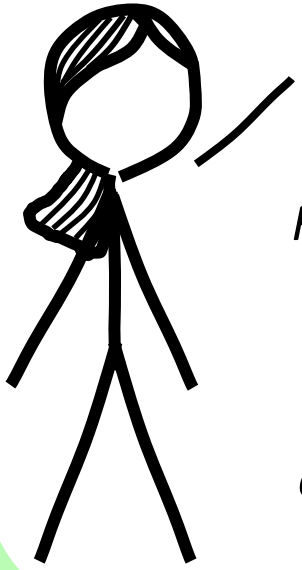
Before coming to lab, you should write an introduction that includes the objective from this slide and includes important equations and concepts from the following slides that are marked with this decal.

1. Overview, formulas, molar mass, %Cu



Today we will analyze a pure salt of copper(II) – maybe it's copper(II) nitrate, or copper(II) acetate, or copper(II) chloride, and so on. We just don't know. It's an unknown!

$CuSO_4(s)$? $Cu(NO_3)_2(s)$? $Cu(C_2H_3O_2)_2(s)$?

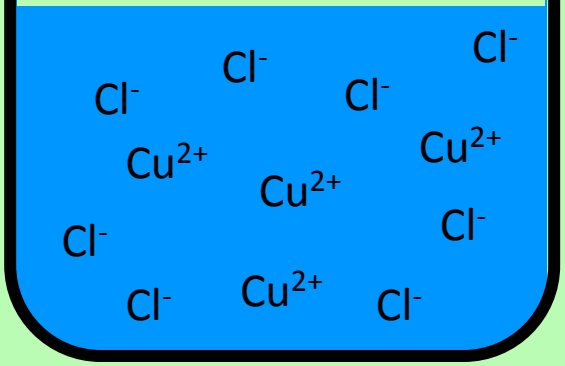


*The unknown may be a **hydrate** like we saw last week – or not.*

*For example, copper(II) chloride exists as **anhydrous** (no waters of hydration) or as a **dihydrate** (2 waters of hydration).*

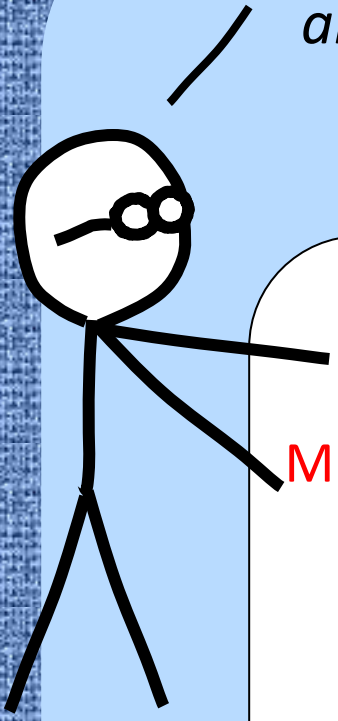
Examples of
solid copper(II) chloride:
As a dihydrate: $CuCl_2 \cdot 2H_2O(s)$
Or as an anydrous solid: $CuCl_2(s)$

Either way, in solution it's just ions:



1. Overview, formulas, molar mass, %Cu

Continuing with copper(II) chloride as an example, the anhydrous version and the dihydrate version have different molar masses and percents copper.



Anydrous copper(II) chloride: $CuCl_2(s)$:

MM = 1 x 63.55 (Cu)
+ 2 x 35.45 (Cl)
= 134.45 g/mol

$$\% \text{ Cu} = 100\% \times \frac{1 \times 63.55}{134.45}$$

= 47.27 % Cu

As a dihydrate: $CuCl_2 \cdot 2H_2O(s)$:

MM = 1 x 63.55 (Cu)
+ 2 x 35.45 (Cl)
+ 4 x 1.008 (H)
+ 2 x 15.999 (O)
= 170.48 g/mol

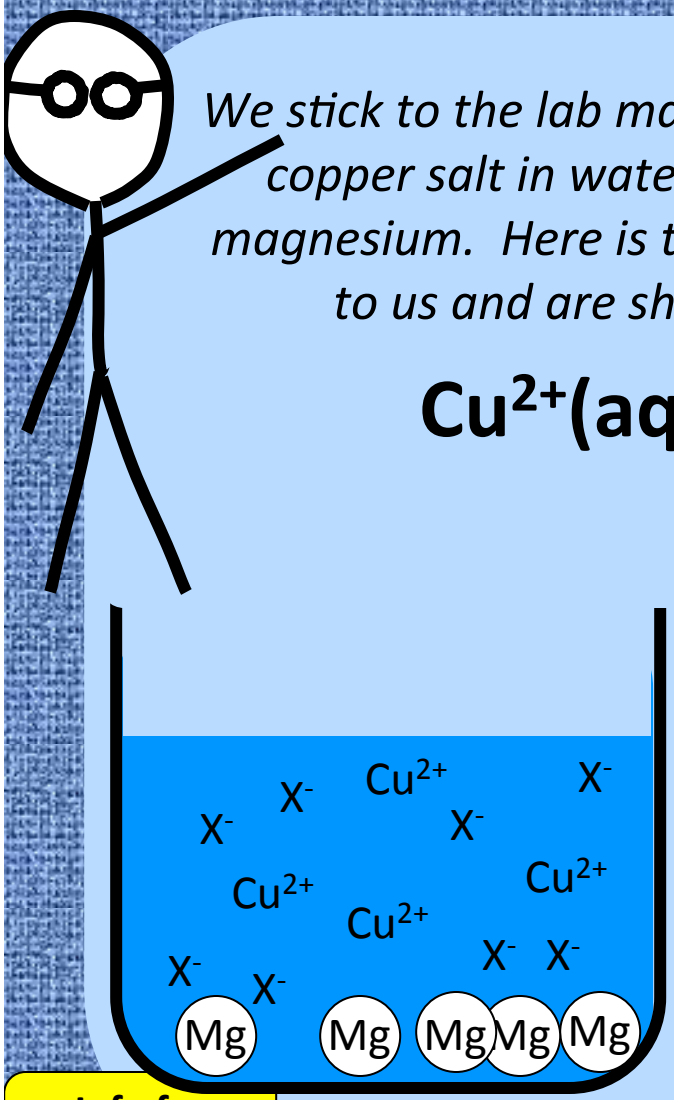
$$\% \text{ Cu} = 100\% \times \frac{1 \times 63.55}{170.48}$$

= 37.28 % Cu

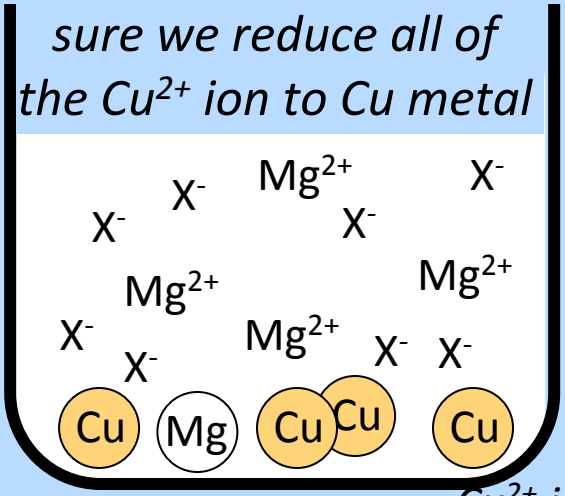
2. Procedure Overview (page 24)

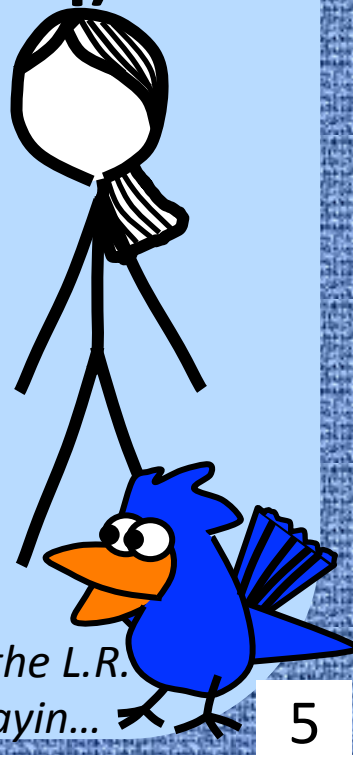
We stick to the lab manual's procedure today. We will dissolve our unknown copper salt in water and reduce the copper(II) ion to copper metal with magnesium. Here is the net ionic equation. The spectator ions are unknown to us and are shown as X^- in the beakers. They might even be X^{2-}.

$Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$



Stir



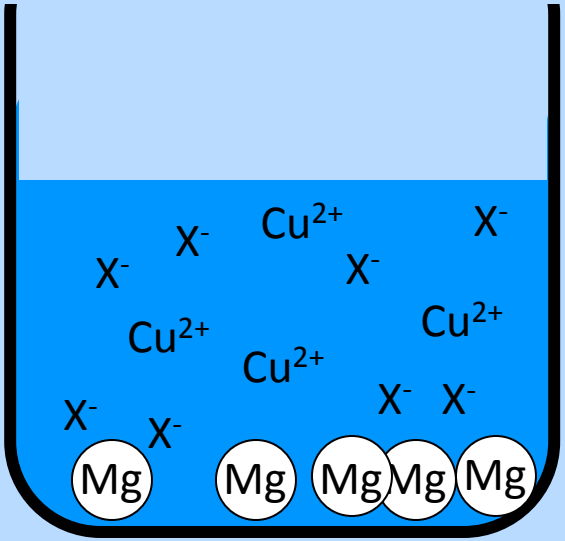


Cu^{2+} is the L.R. Just sayin…

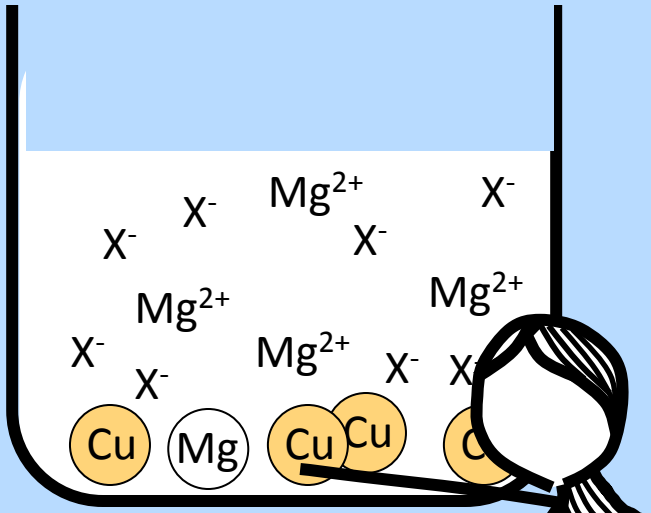
Info for Introduction

2. Procedure Overview (page 28)

$Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$



Stir

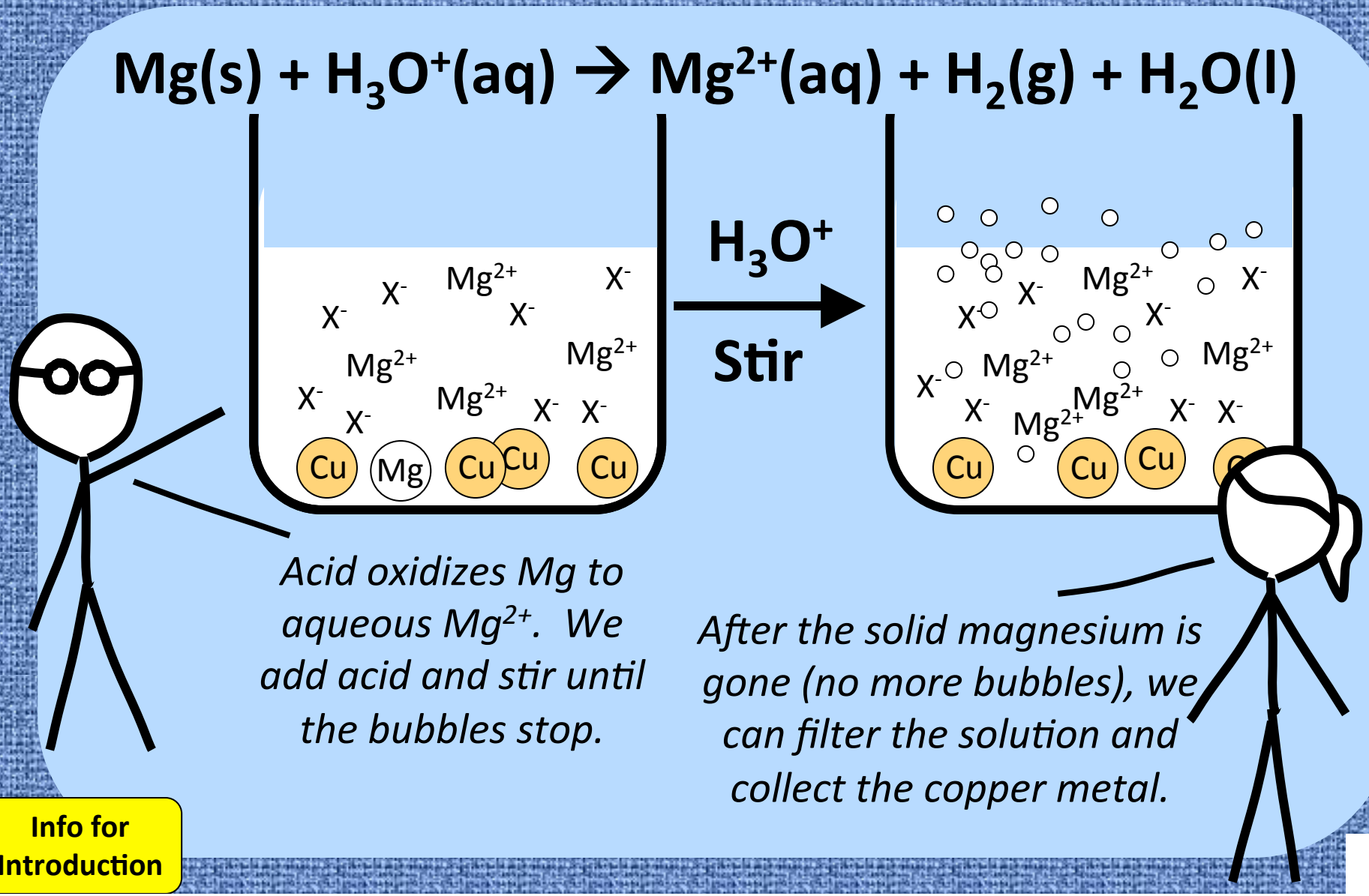


You can tell when the reaction is over – all of the blue Cu^{2+} is gone and the solution is colorless. You should see orange copper metal.

Next we have to get rid of excess solid Mg or it will add to the weight of the solid copper and mess up our results.

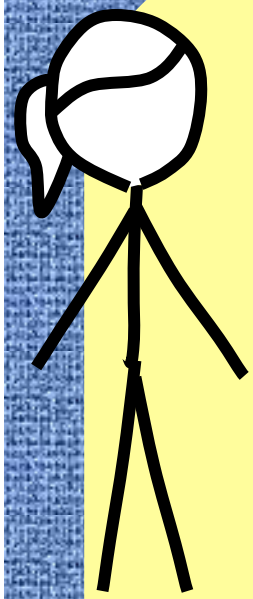
Info for Introduction

2. Procedure Overview (page 28)



Info for Introduction

3. Calculations



From the mass of copper we can get moles of copper and because the unknown has only one copper atom, the moles of unknown equals the moles of copper! Easy peasy.

$$m_{Cu} \rightarrow n_{Cu} \rightarrow n_{unknown}$$

Percent copper and molar mass are easy formulas to use. Watch out for significant figures and units.

$$\%Cu = 100\% \times \frac{m_{Cu}}{m_{unknown}} \qquad MM = \frac{m_{unknown}}{n_{unknown}}$$

Info for calculations

3. Calculations

So we end up with two important measurements today – the mass of the unknown and the mass of copper in the unknown.

Getting the mass of copper right is the trick. If you lose some Cu during filtration, your % Cu will be too low. If the Cu is wet, the mass will be too high and so will the %Cu

$$\%Cu = 100\% \times \frac{m_{Cu}}{m_{unknown}}$$

Not so easy to mess up the mass of the unknown…

Info for calculations

3. Calculations

$m_{Cu} \rightarrow n_{Cu} \rightarrow n_{unknown}$

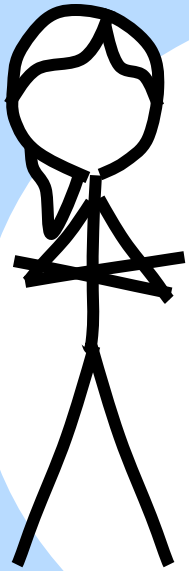
Remember how mass of copper gives us moles of copper and that gives us moles of unknown? Yeah. So errors with the mass of copper will cause errors with the molar mass as well.

If you lose some copper during filtration, your moles of copper and therefore moles of unknown will be too low. That will make your molar mass too high. If the Cu is wet, molar mass will be too low.

$$MM = \frac{m_{unknown}}{n_{unknown}}$$

Info for calculations

3. Calculations

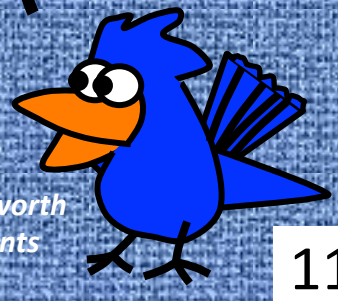


This is the first experiment in which we are being graded for accuracy!

…and sig figs

…and units

Hmmm… If I get the mass of the copper right, I should be good.



Your copper is worth about 0.72 cents

3. Calculations

The lab manual gives us some choices for the correct identity of the unknown. Our unknown is one of these.

Which one is it? And what is the percent error for molar mass?

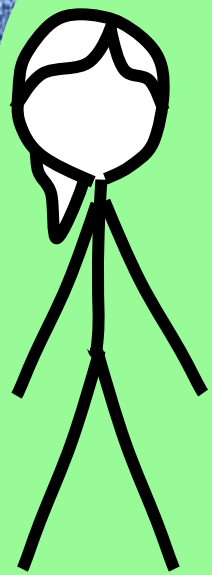
$CuBr_2$	MM = 223.4 g/mol
$Cu(C_2H_3O_2)_2 \cdot H_2O$	MM = 199.6 g/mol
$CuCl_2 \cdot 2H_2O$	MM = 170.5 g/mol
$CuCO_3$	MM = 123.6 g/mol
$CuSO_4 \cdot 5H_2O$	MM = 249.7 g/mol

$$\text{\% Error} = 100\% \times \frac{\text{difference}}{\text{actual}}$$

Sometimes you can't decide between two. Conclude it may be either – don't just pick one – that's not good science.

Info for calculations

4. Procedure for today (pg. 24)



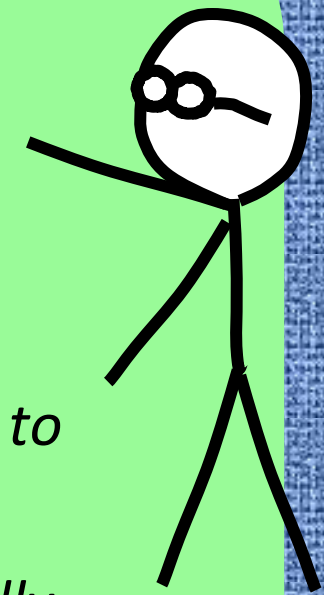
I. *Wear your safety glasses today. And we need Level 1b-i-ii-iii attire today.*

II. *We follow the manual carefully.*

III. *Use an analytical balance for measuring masses of copper unknown and copper today. Use the little scale at your station to measure the magnesium.*

IV. *Record observations and details as carefully as possible.*

V. *Instead of Step 11, turn in your copper in a weighing boat. Make a label with your names and lab station and section.*



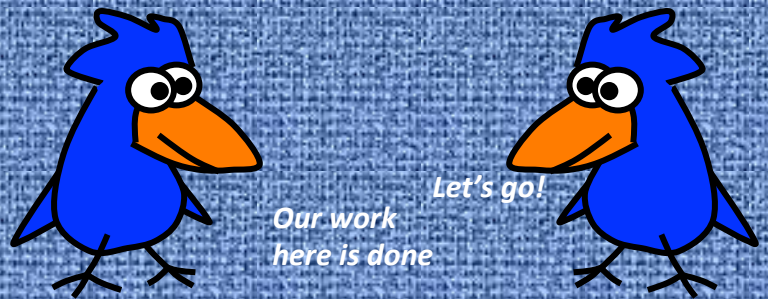
5. Your lab report.

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.

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



Stick people inspired by xkcd cartoons by Randall Munroe