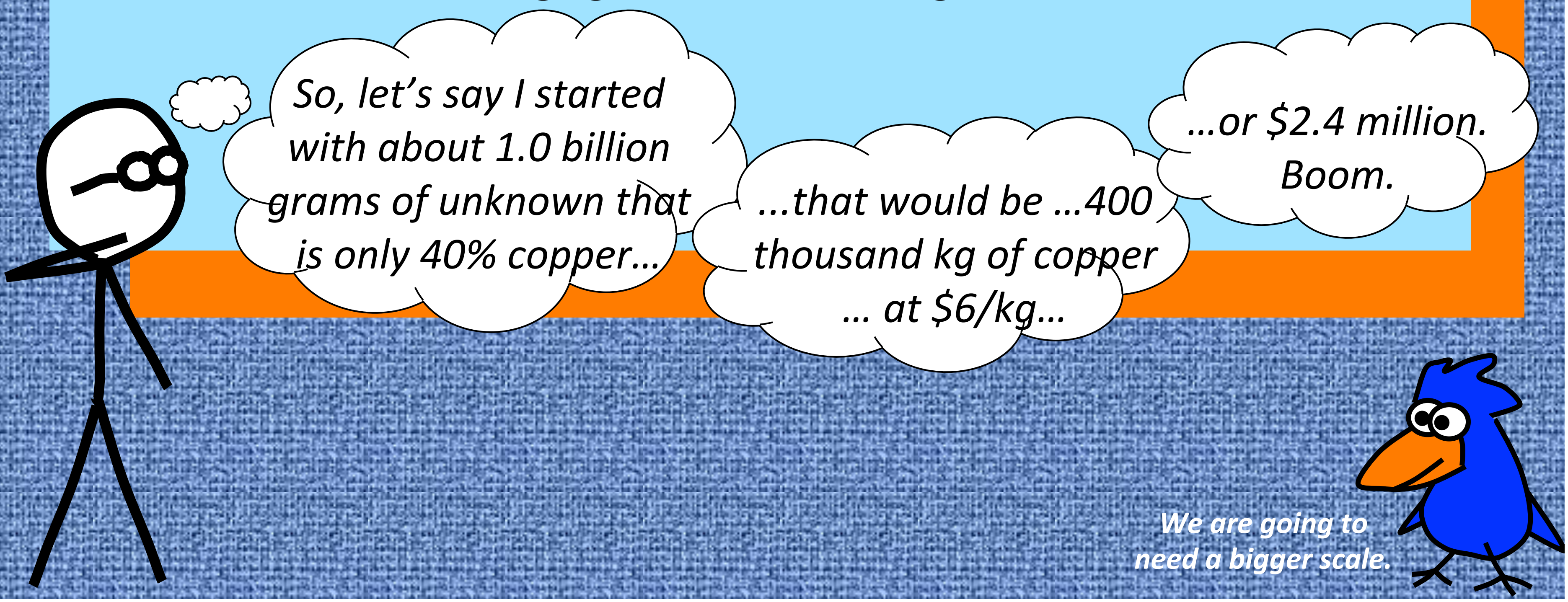
Experiment 3
11 September 2018
Percent Copper and Molar Mass of a Copper Compound



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!

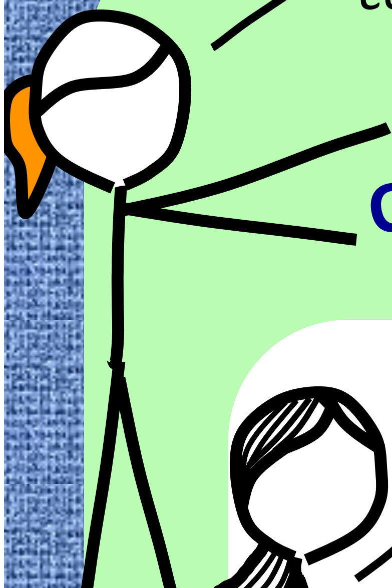
Overview:

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

Remember, 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 sign.

Info for Introduction

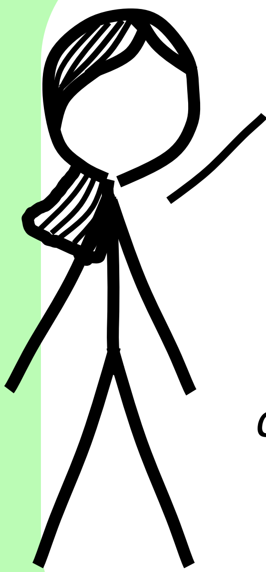
1. Overview, formulas, molar mass, %Cu



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!

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

$Cu(C_2H_3O_2)_2(s)$?



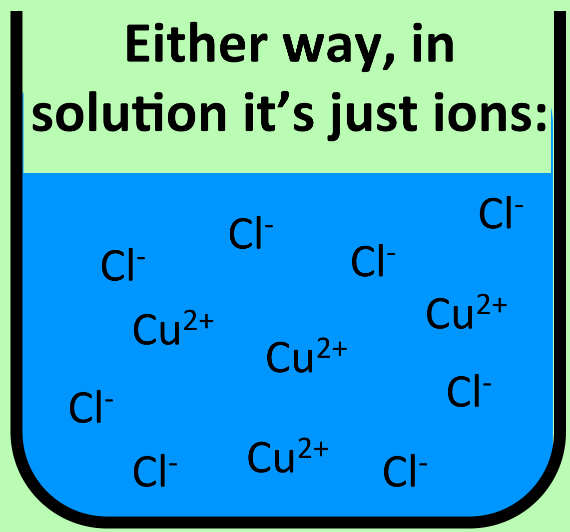
*The unknown may be a **hydrate** – a salt that includes water in its formula. Or not.*

*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:

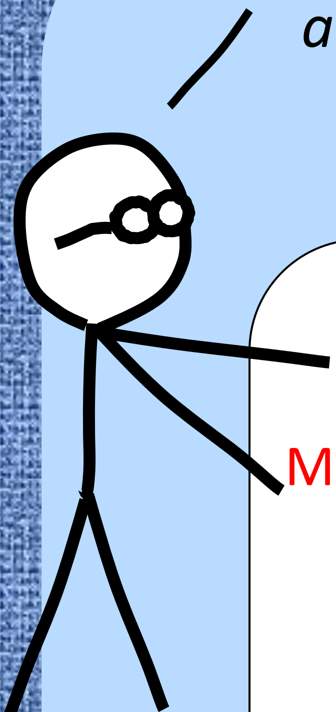
As a dihydrate: $CuCl_2 \cdot 2H_2O(s)$

Or as an anydrous solid: $CuCl_2(s)$



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

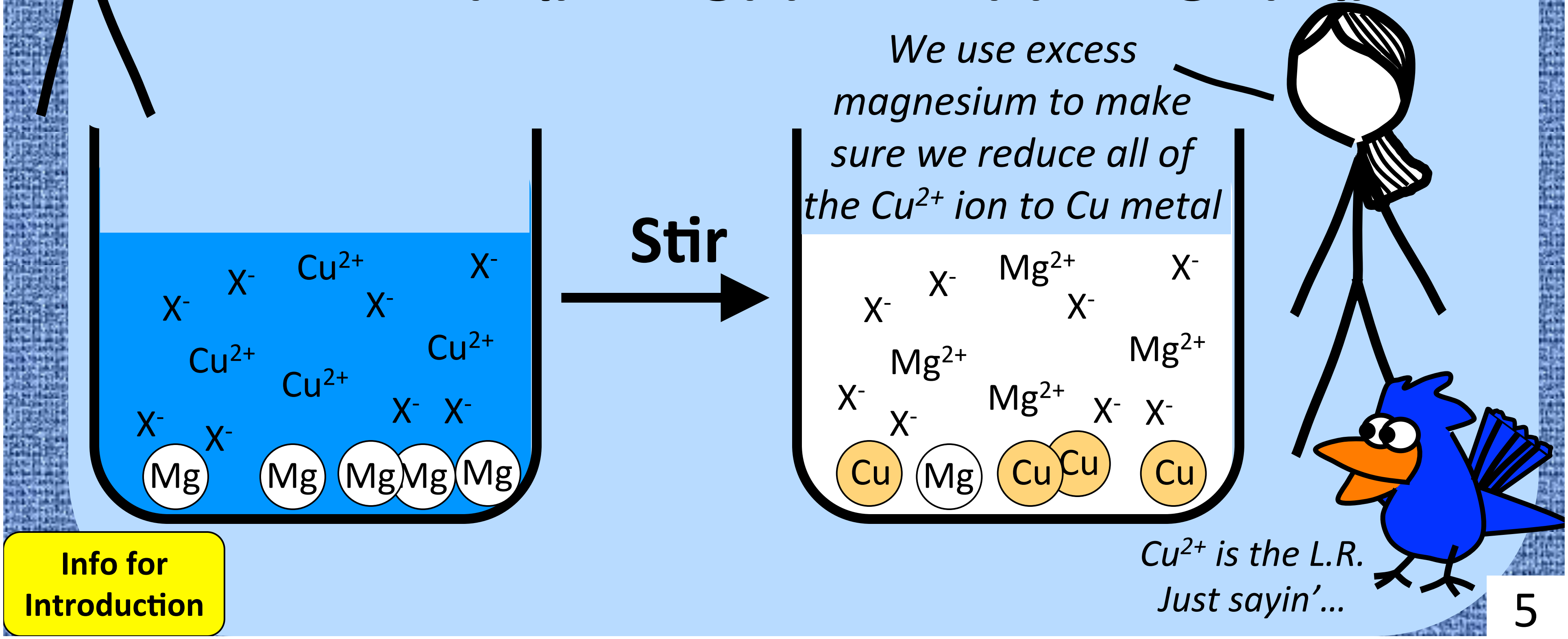
$$\% \text{ Cu} = 100\% \times \frac{1 \times 63.55}{170.48}$$

= 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-}.

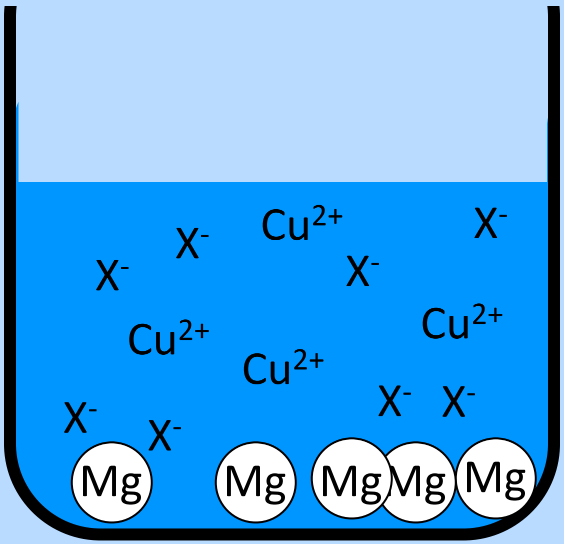
$$Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$$

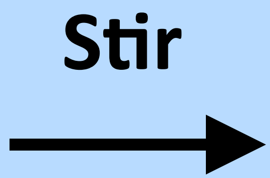


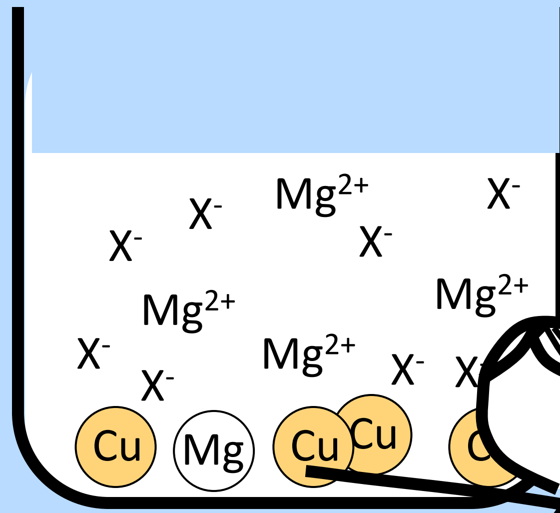
Info for Introduction

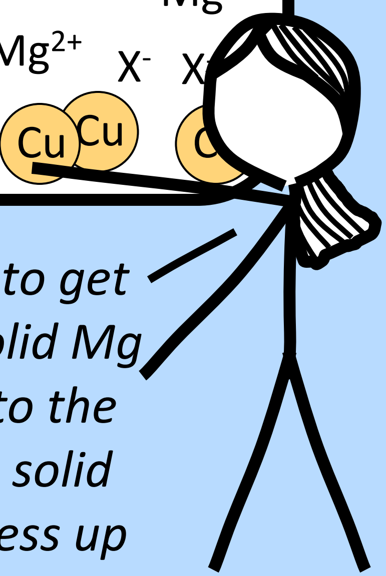
2. Procedure Overview (page 24)

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









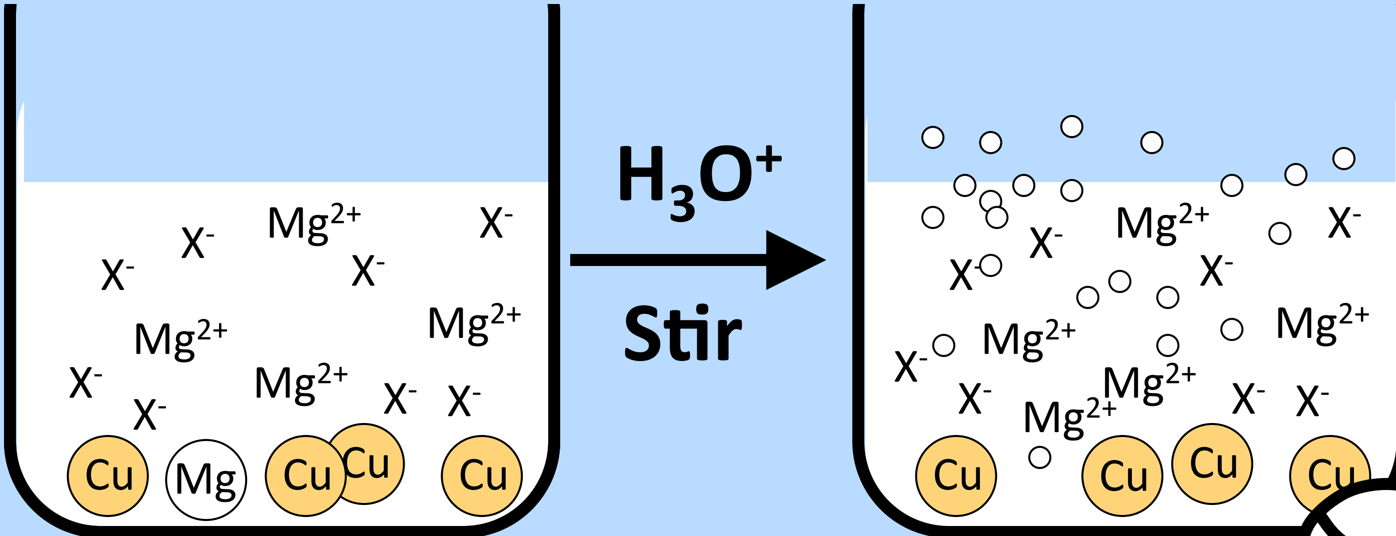
You can tell when the reaction is over – all of the blue Cu^{2+} is gone and the solution is colorless. You should see orange copper metal.

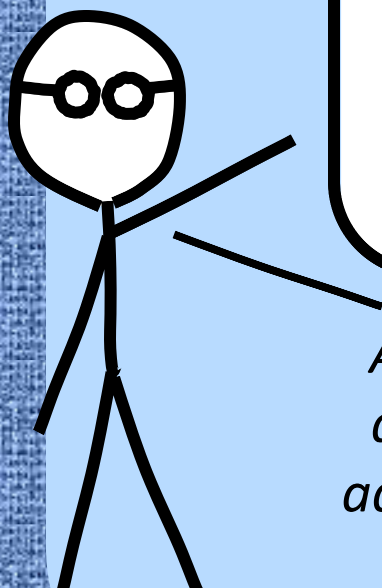
Next we have to get rid of excess solid Mg or it will add to the weight of the solid copper and mess up our results.

Info for Introduction

2. Procedure Overview (page 24)

$$\mathbf{Mg(s) + H_3O^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g) + H_2O(l)}$$



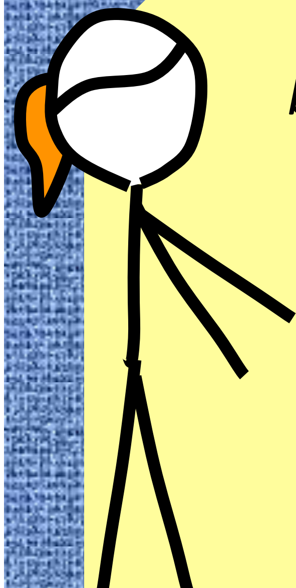


Acid oxidizes Mg to aqueous Mg^{2+}. We add acid and stir until the bubbles stop.

After the solid magnesium is gone (no more bubbles), we can filter the solution and collect the copper metal.

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.

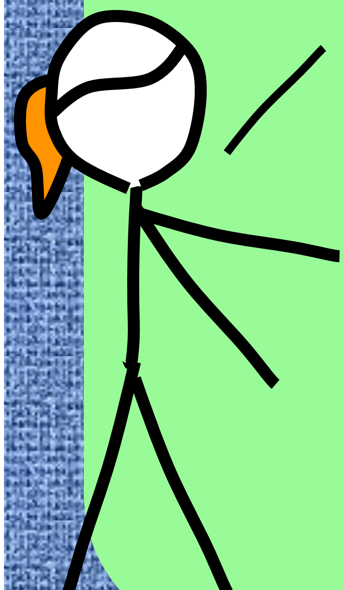
$$m_{Cu} \rightarrow n_{Cu} \rightarrow n_{unknown}$$

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

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

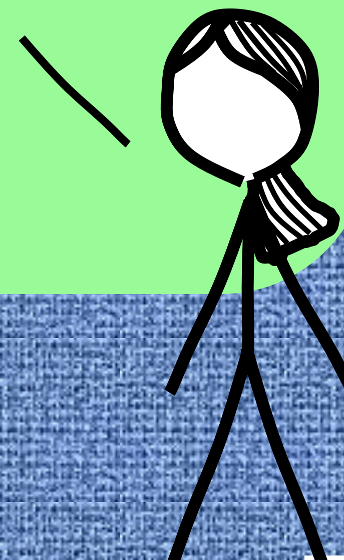
Info for calculations

3. Calculations

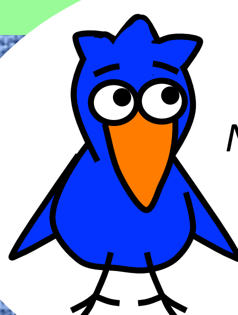


So we end up with two important measurements today – the mass of the unknown and the mass of copper in the unknown.

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

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

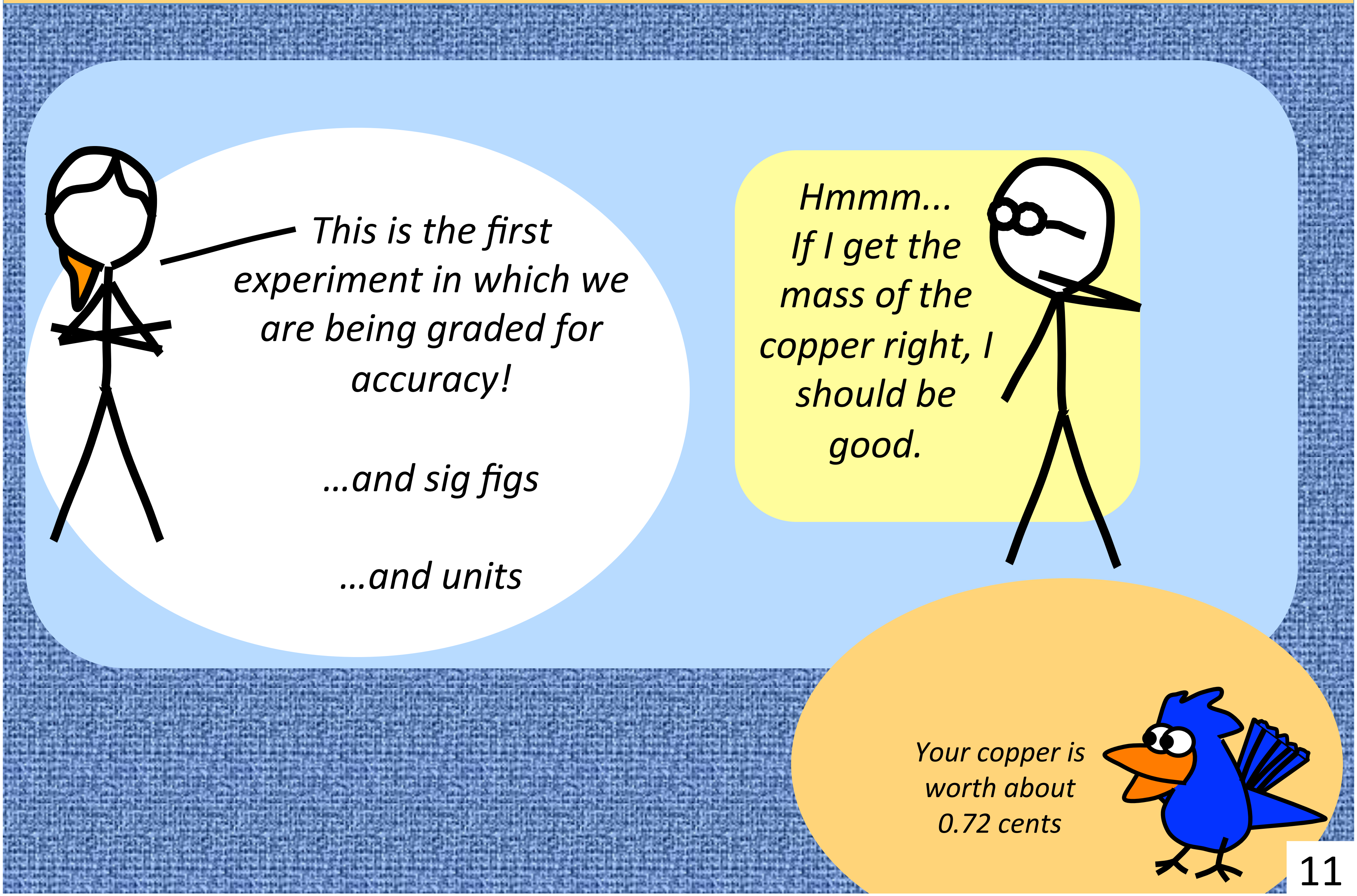
Remember how mass of copper gives us moles of copper and that gives us moles of unknown? Yeah. So errors with the mass of copper will cause errors with the molar mass as well.

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.

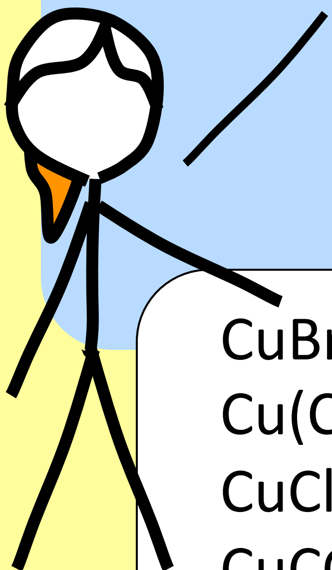
$$MM = \frac{m_{unknown}}{n_{unknown}}$$

Info for Sources of Error

3. Calculations



3. Calculations



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

$CuBr_2$	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

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

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

Sometimes you can't decide between two. Conclude it may be either – don't just pick one – that's not good science. BTW, I have a luncheon right after this. Hence the tux.

Info for calculations

4. Procedure for today (pg. 24)

I. Wear your safety glasses today. And we need to dress for a mess 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. Conclusions. We'll learn more on the next slide.

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

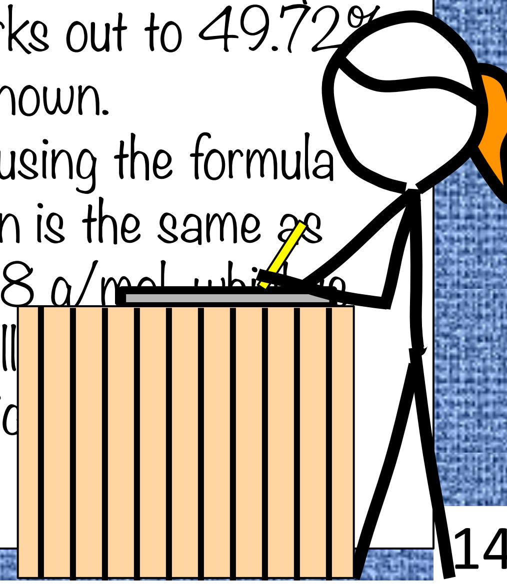
5. Your lab report.

In the conclusion we can summarize what we've learned. Why did we do this experiment? Review the Objectives from Slide 2 and see if we did what we set out to do. We read your conclusions carefully. Be sure to write it in your own words and not copy it from anyone.

Conclusion.

In this experiment we determined the percent copper in an unknown salt of copper(II). To do this we needed the mass of the unknown salt and the mass of the copper it contained. In our case, we used 2.514 g unknown and ended up with 1.250 g copper metal, which is 0.1967 mol Cu. That works out to 49.72% copper using the formula %Cu = 100% X mass Cu/mass unknown.

We also determined the molar mass of the unknown using the formula MM = mass unknown/moles unknown. The moles of unknown is the same as the moles of copper. We got 2.514 g/0.01967 moles = 127.8 g/mol which most similar to $CuCO_3$ from the list of choices. If that is actuall the unknown, we are off by just 3.4%. None of the other choic close, so we are confident about the identity of our unknown.



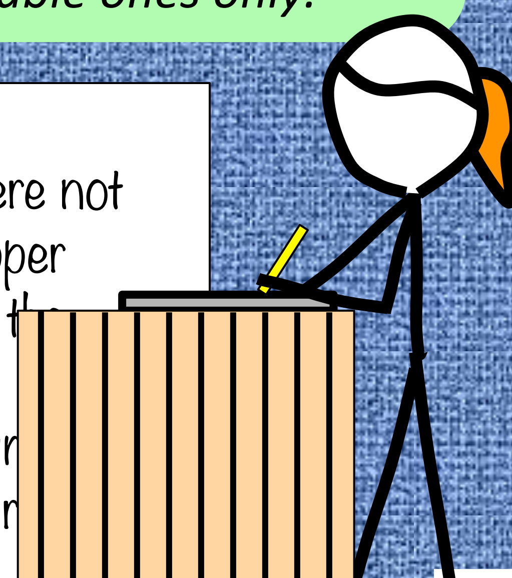
5. Your lab report.

Reasonable	Not too likely	Unreasonable
Copper was wet or Some copper was lost	Used the balance incorrectly Sample was impure	Laws of physics suspended. Sabotaged by TAs

We also address sources of errors. Sometimes there aren't any obvious ones and other times there are plenty. We need to only worry about the more plausible ones. Looking over the continuum of possible errors for this experiment, we will stick with the reasonable ones only.

Sources of error.

In the context of our good results, errors probably were not significant for us. However, we can see how maybe some copper could have been lost during the filtering. If that had happened, t
percent copper would be too low and the molar mass too high.
other hand, if the copper were a bit wet or had some magnesiu
the percent copper would calculate to be too high and the molar
too low. We feel that no major errors were encountered.



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