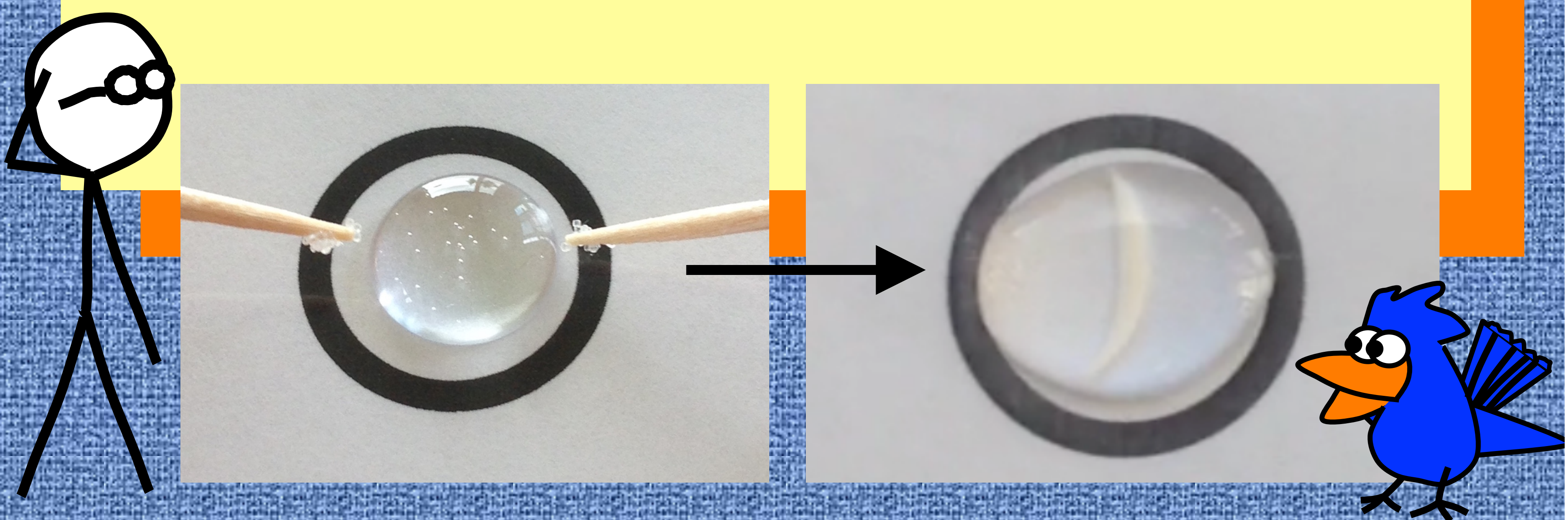
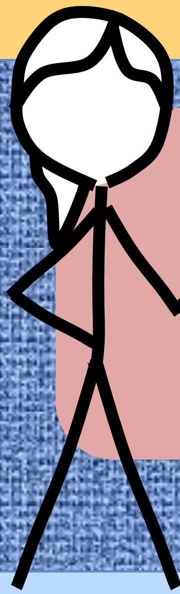
Experiment 6
1 October 2019
Microscale Precipitation Reactions

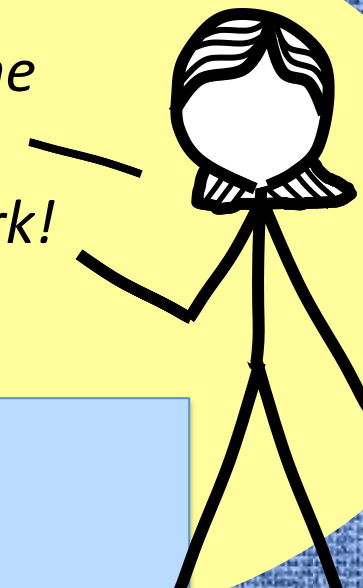


Objectives: To observe the dissolving process and formation of a precipitate.



Today we explore some of the precipitation reactions we studied in Chapter 4.

We'll see the Solubility Rules at work!

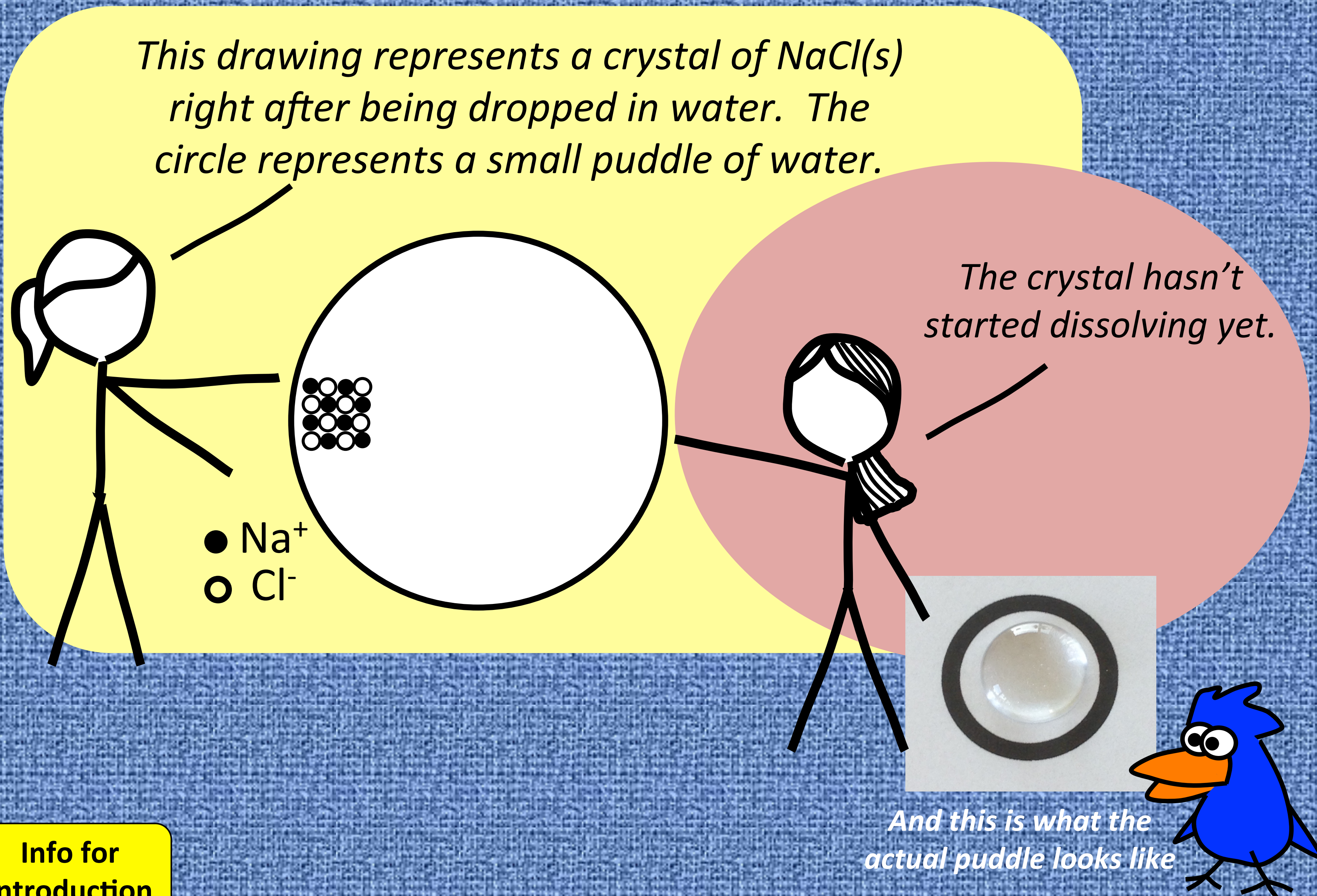


Overview:

1. How salts dissolve and ions migrate
2. Overview (YouTube videos)
3. Procedure: Watching and writing precipitation reactions
4. Discussion of Solubility Rules
5. Lab today and your lab report

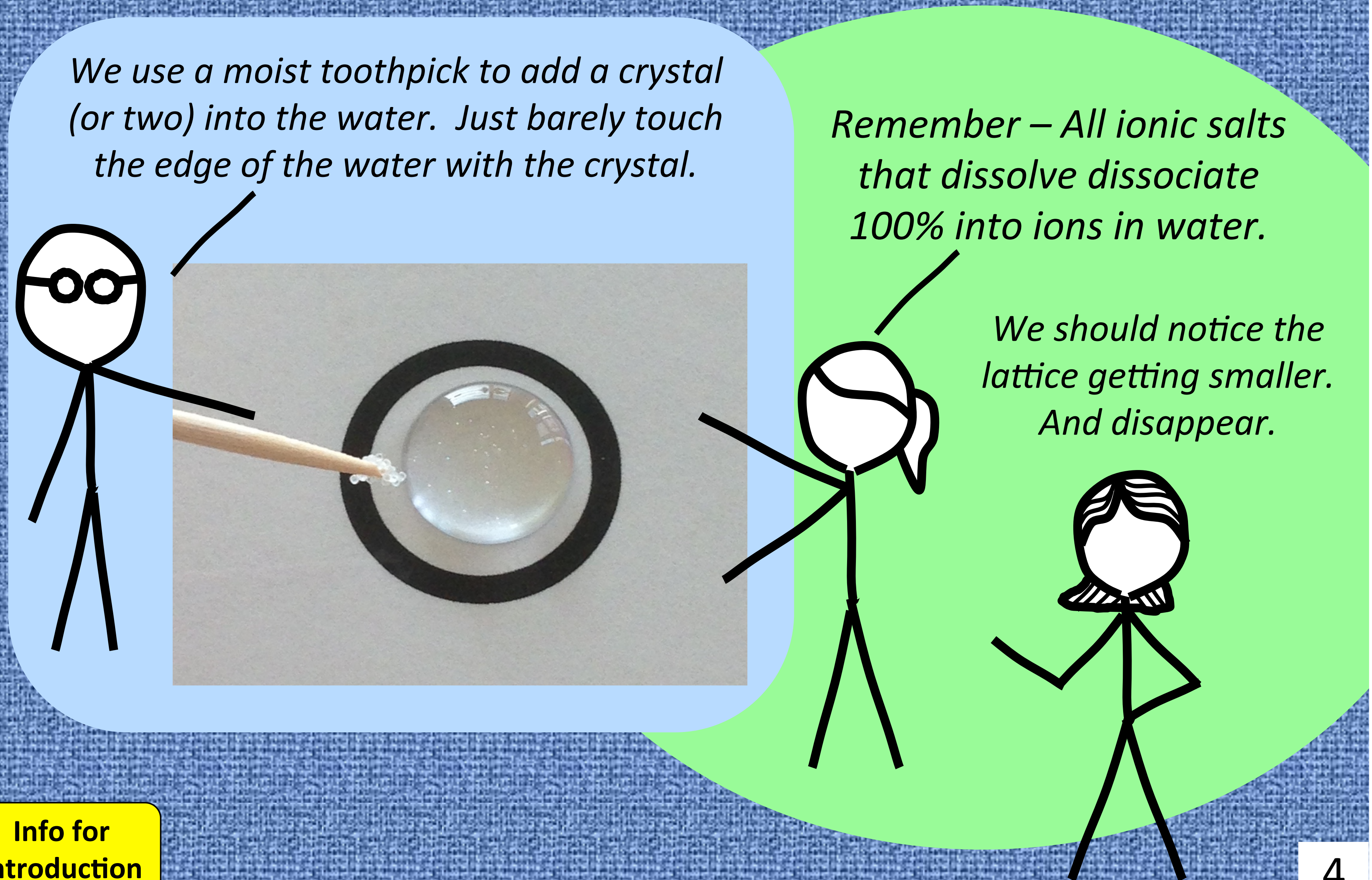
Bring on the precipitation!

1. How salts dissolve and ions migrate



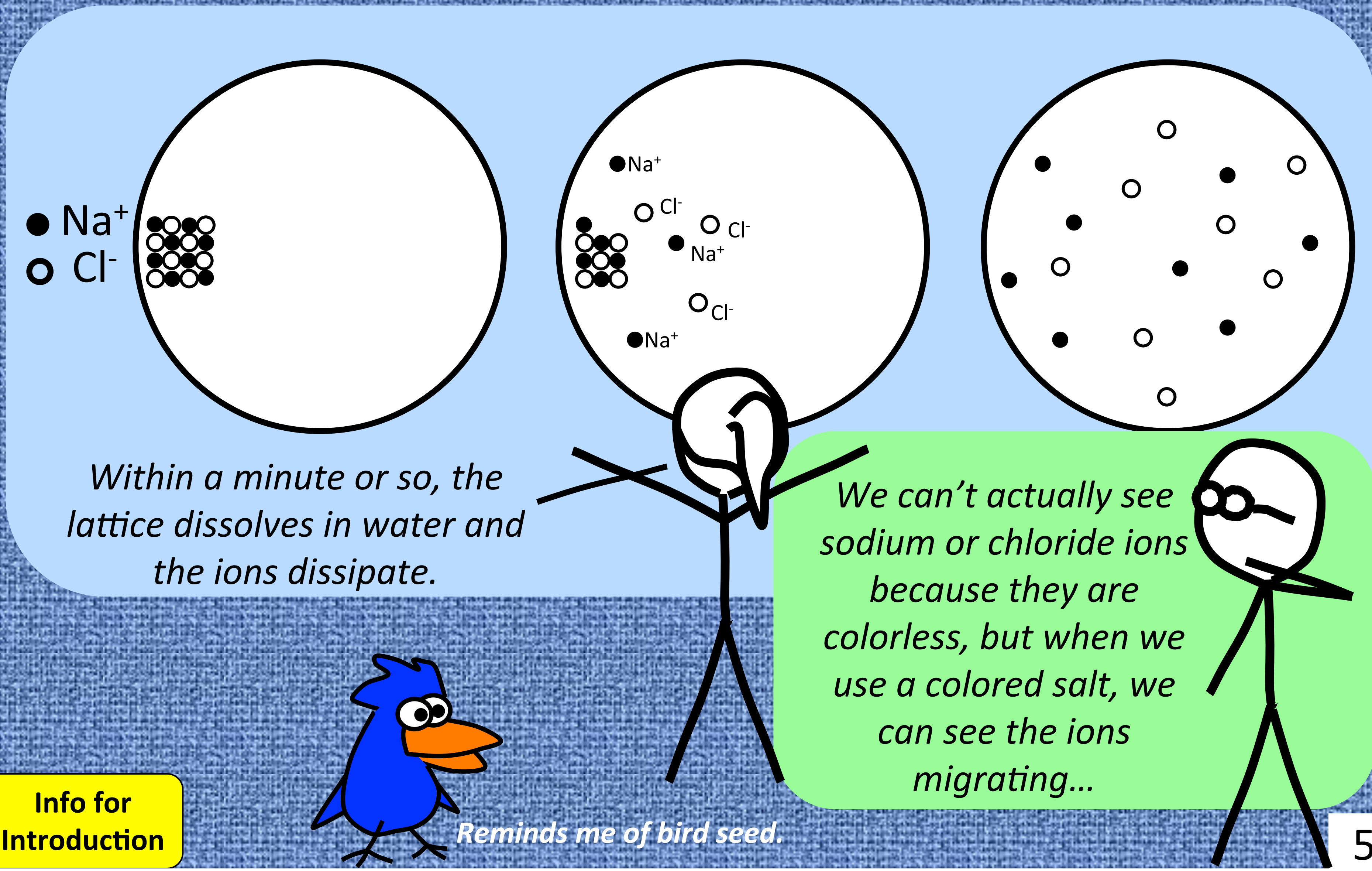
Info for Introduction

1. How salts dissolve and ions migrate



Info for Introduction

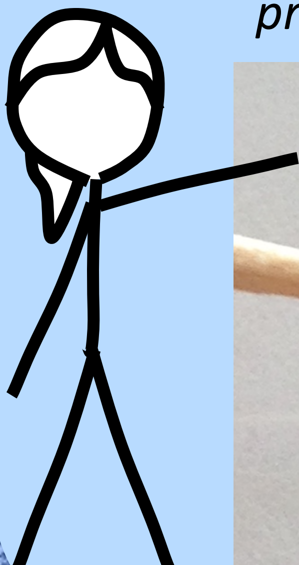
1. How salts dissolve and ions migrate

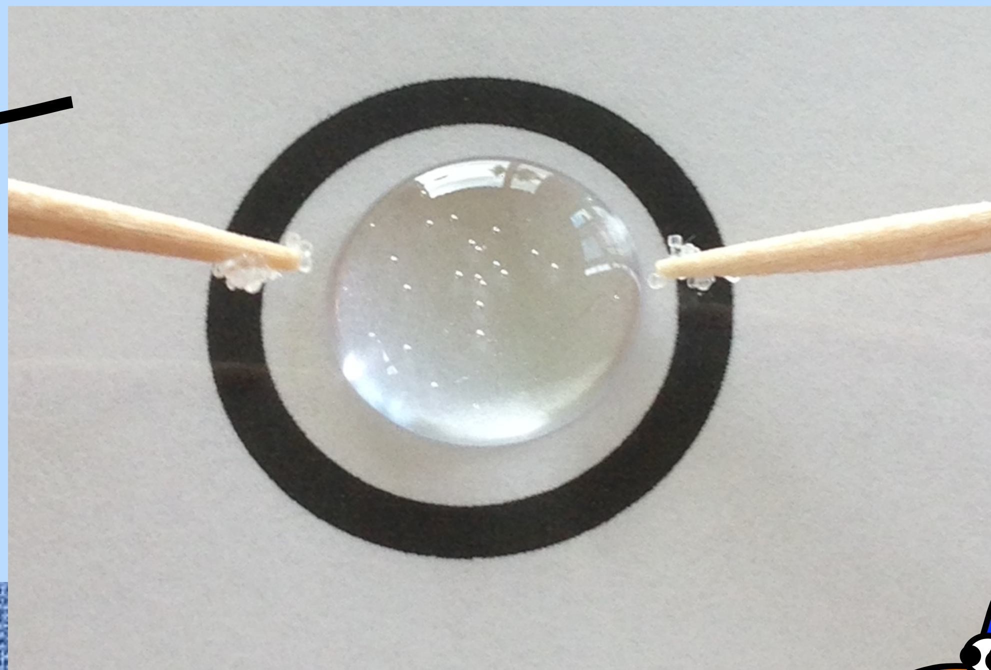


Info for Introduction

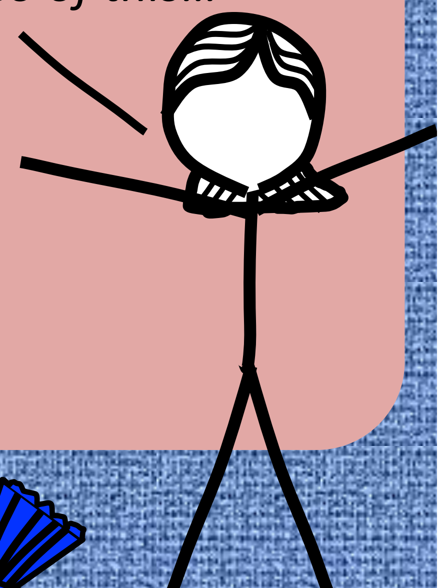
2. Overview

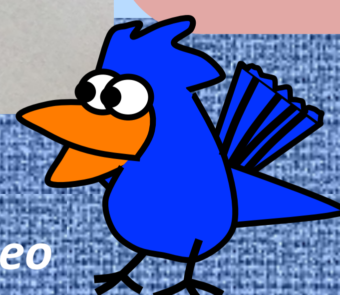
*However, in this experiment we add **two** salts simultaneously on opposite sides of the puddle. Then we will watch as a precipitate forms. It usually takes just a minute or so.*





Let’s watch a video of this…





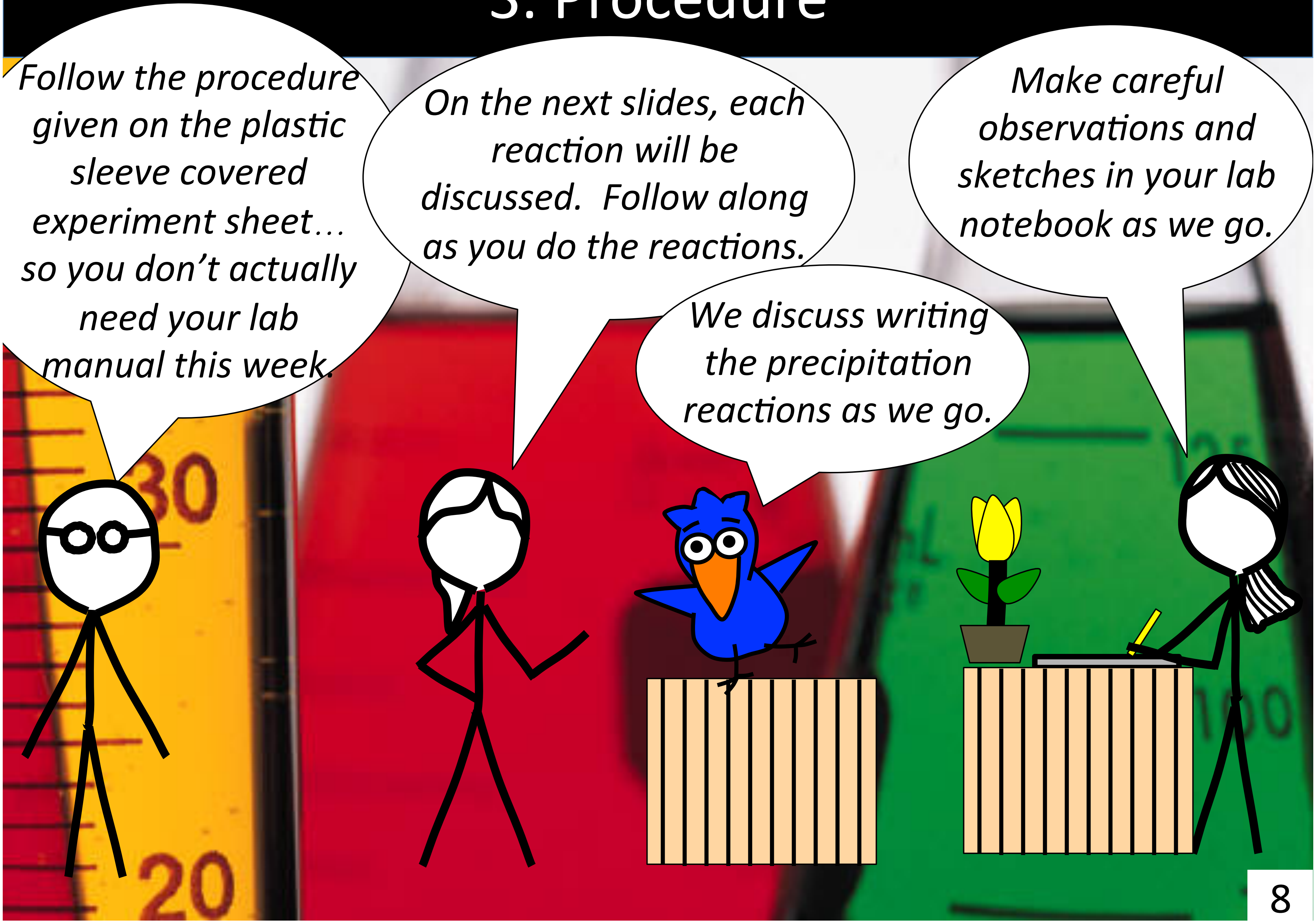
Oo! A video

Info for Introduction

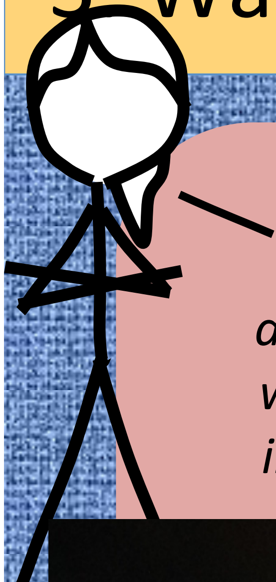
2. Overview

The video: https://www.youtube.com/watch?v=f2FA1p5KHCE&feature=youtu.be

3. Procedure

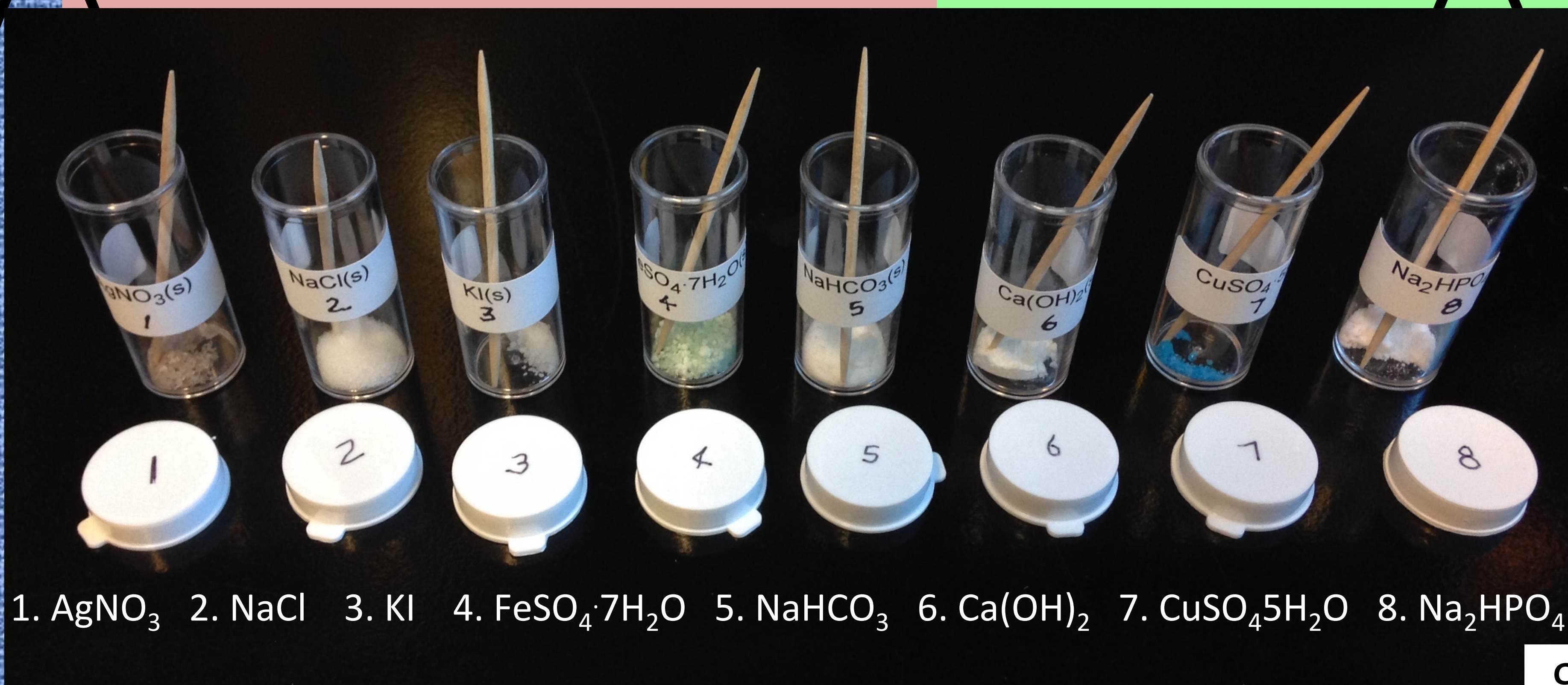

Follow the procedure given on the plastic sleeve covered experiment sheet… so you don't actually need your lab manual this week.
On the next slides, each reaction will be discussed. Follow along as you do the reactions.
We discuss writing the precipitation reactions as we go.
Make careful observations and sketches in your lab notebook as we go.

3. Watching and writing precipitation reactions



We will perform a total of five experiments today and most, but not all, will form precipitates. The solids we will use are similar to those shown here in numbered vials with numbered caps.

Keep the toothpicks with their respective vials. Be careful not to switch toothpicks around.



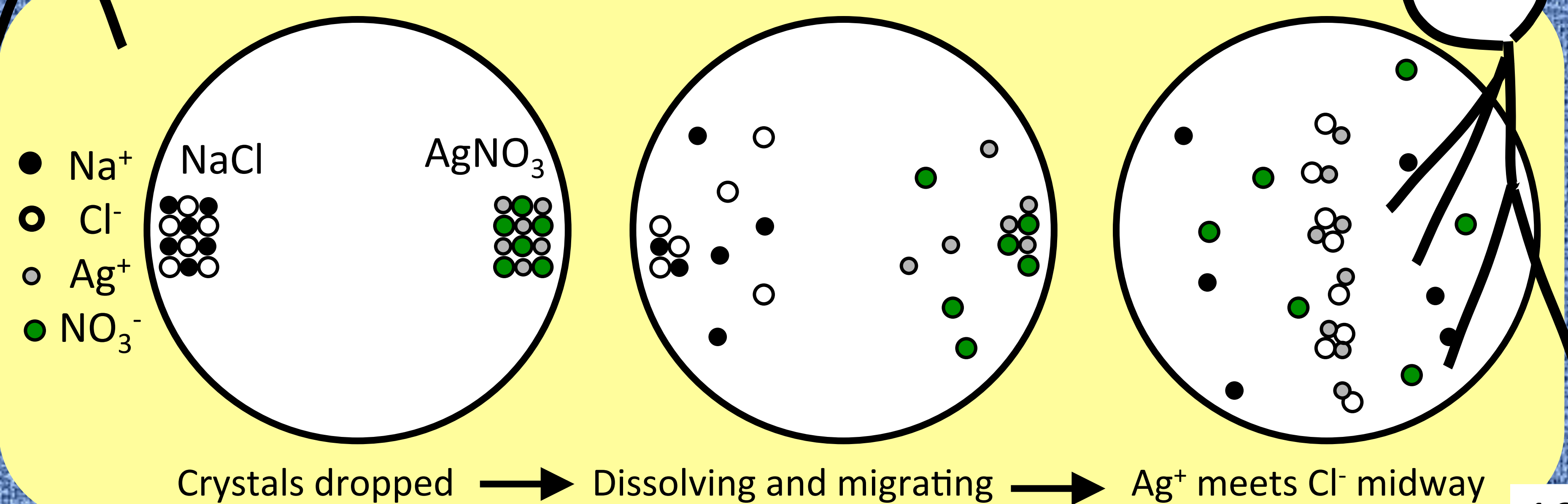
3. Watching and writing precipitation reactions

Let's discuss the reaction from the video which is also Experiment 1. The crystals start by dissolving to make ions as shown here:

$$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$$

$$AgNO_3(s) \rightarrow Ag^{+}(aq) + NO_3^{-}(aq)$$

See? The precipitate forms right in the middle and is represented as the ions paired up. The cloudiness you notice is the beginning of an ionic lattice



3. Watching and writing precipitation reactions

Here is the whole story. First, the crystals dissolve to make ions:

$$NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$$

$$AgNO_3(s) \rightarrow Ag^+(aq) + NO_3^-(aq)$$

And here the ions migrate and eventually form a precipitate where they meet in the middle. The ***ionic*** *equation is:*

$$Na^+(aq) + Cl^-(aq) + Ag^+(aq) + NO_3^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq)$$

And here are the ***net ionic*** *and* ***overall*** *equations.*

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

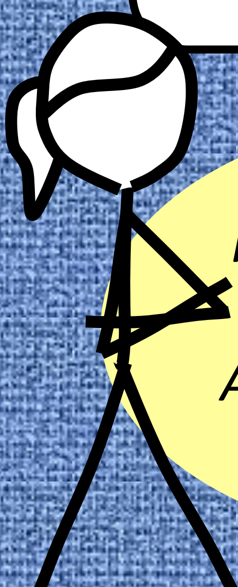
3. Watching and writing precipitation reactions

*For each reaction that we do, we are asked to write the **overall reaction**, and the **net ionic reaction**. Here they are:*

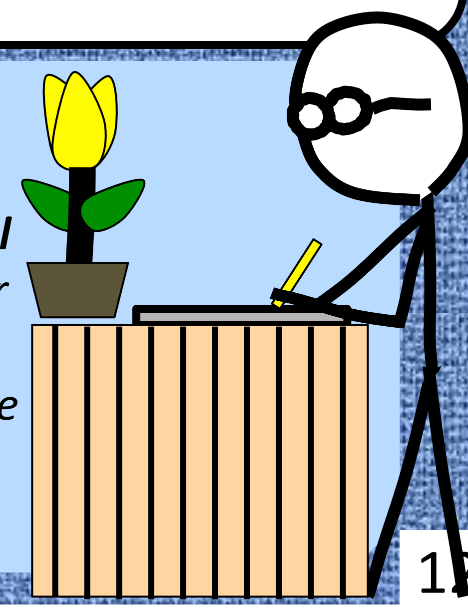
We don't have to write the ionic equation – like we saw on the previous slide in red.

Overall: $NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

Net ionic: $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

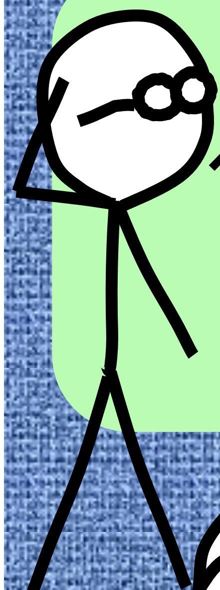


Now you try it for the second reaction, $AgNO_3(aq)$ and $KI(aq)$.



*BTW, Our book and lab manual use **molecular reaction** instead of **overall reaction**. We kinda prefer overall reaction because none of the compounds are molecules. You can do either.*

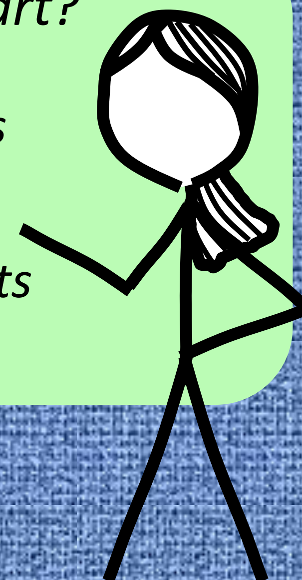
3. Watching and writing precipitation reactions



What Solubility Rules explains the crystals dissolving part?

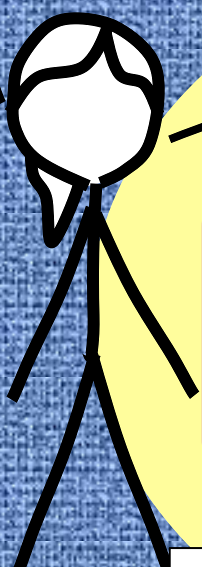
$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$

$AgNO_3(s) \rightarrow Ag^{+}(aq) + NO_3^{-}(aq)$



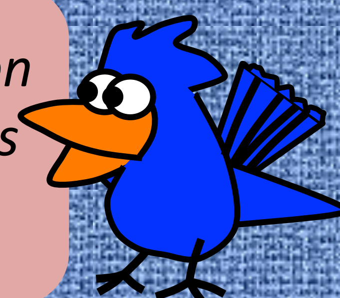
All Group I salts are soluble.

All nitrate salts are soluble.



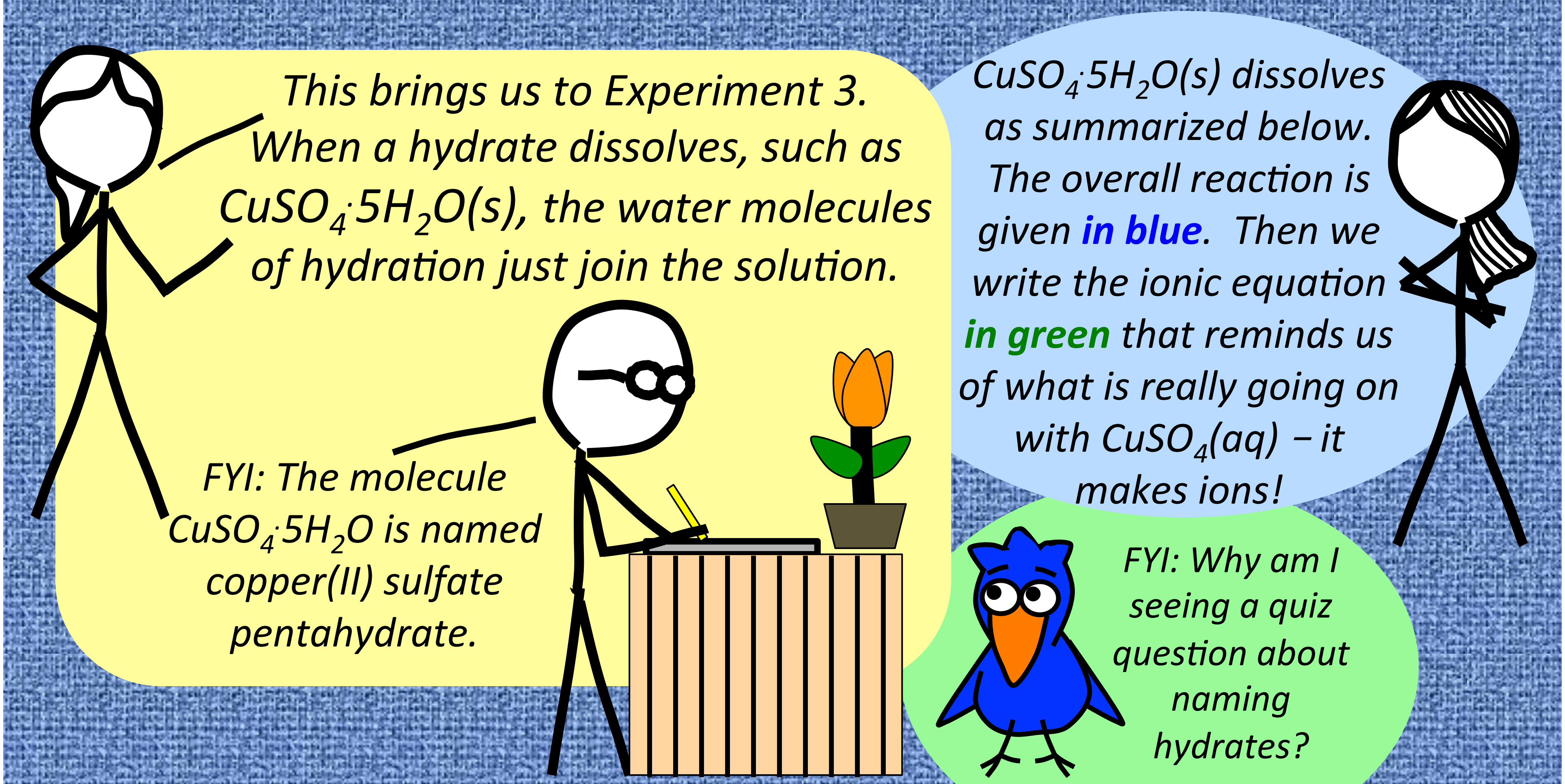
So what precipitated and what Solubility Rule explains it?

Just ask the Solubility Bird! The net ionic reaction is given below. And the rule is: All chloride salts are soluble except for AgCl, $PbCl_2$ and Hg_2Cl_2.



$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$

3. Watching and writing precipitation reactions

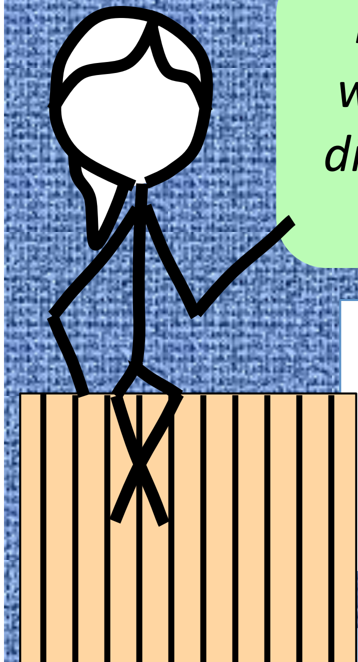


Overall equation for dissolving and then the ionic equation:

Dissolving: $CuSO_4{\cdot}5\ H_2O(s) \rightarrow CuSO_4(aq) + 5\ H_2O(l)$

Forming ions: $CuSO_4(aq) \rightarrow Cu^{2+}(aq) + SO_4^{2-}(aq)$

3. Watching and writing precipitation reactions



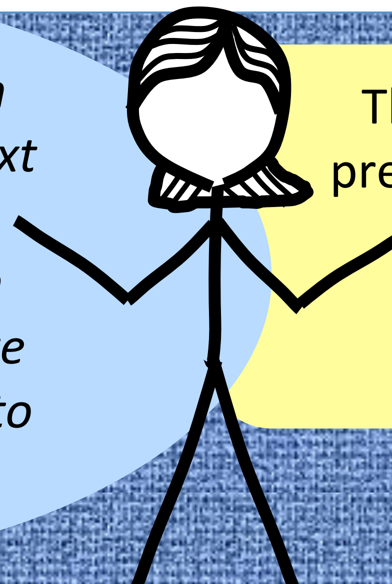
Here are the equations for what happens when sodium hydrogen phosphate crystals dissolve. Always start this way so you know what ions will precipitate.

Overall equation for dissolving and ionic equation:

Dissolving: $Na_2HPO_4(s) \rightarrow Na_2HPO_4(aq)$

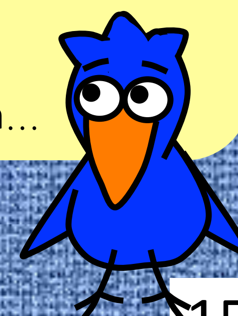
Forming ions: $Na_2HPO_4(aq) \rightarrow 2\ Na^+(aq) + HPO_4^{2-}(aq)$

So when we write precipitation reactions, like the one on the next slide, we start with aqueous solutions of the ions. And with reactions that involve phosphate precipitates, we are only going to write net ionic reactions.



The ions that lead to precipitate are $Cu^{2+}(aq)$ and $HPO_4^{-}(aq)$

Huh…



The Procedure

3. Watching and writing precipitation reactions

Let's talk about Experiment 3.

We will help you out with it.

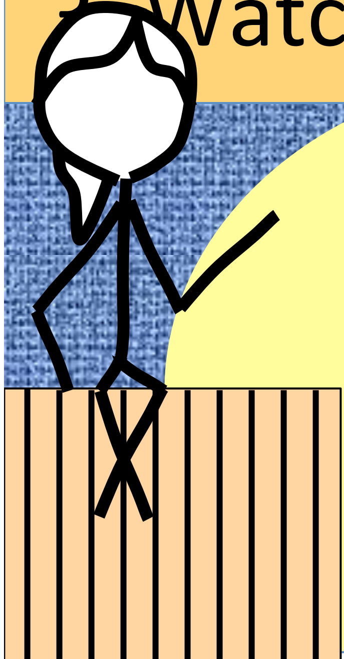
*I'll just say it: The hydrogen phosphate ion, HPO_4^{2-} , works just like phosphate ion, PO_4^{3-}, and makes phosphate precipitates, as you can see in this **net ionic equation**…*

$$3\ Cu^{2+}(aq) + 2\ HPO_4^{-}(aq) \rightarrow Cu_3(PO_4)_2(s) + 2\ H^{+}(aq)$$

This is what she's just saying. Cu^{2+} and hydrogen phosphate, HPO_4^{-2} form the predicted copper(II) phosphate precipitate, $Cu_3(PO_4)_2(s)$… The 3 and 2 stoichiometry is because copper is +2 and the phosphate ion has a -3 charge, PO_4^{-3}.

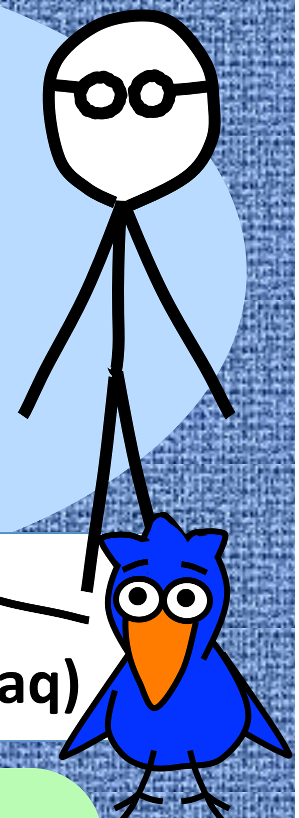
*For reactions with hydrogen phosphate and hydrogen carbonate**, we are only going to write the net ionic equations**. That's easy… well kinda…*

3. Watching and writing precipitation reactions



This slide is about the overall reaction and we are just showing it to you. Today you will only need to write the net ionic reactions for these tougher reactions.

*Each Cu^{2+} brought a sulfate ion with it as a spectator ion. Each hydrogen phosphate, HPO_4^-, brought two sodium ions with it as spectator ions, so **here is the overall reaction**:*



$3\ CuSO_4(aq) + 2\ Na_2HPO_4(aq) \rightarrow$

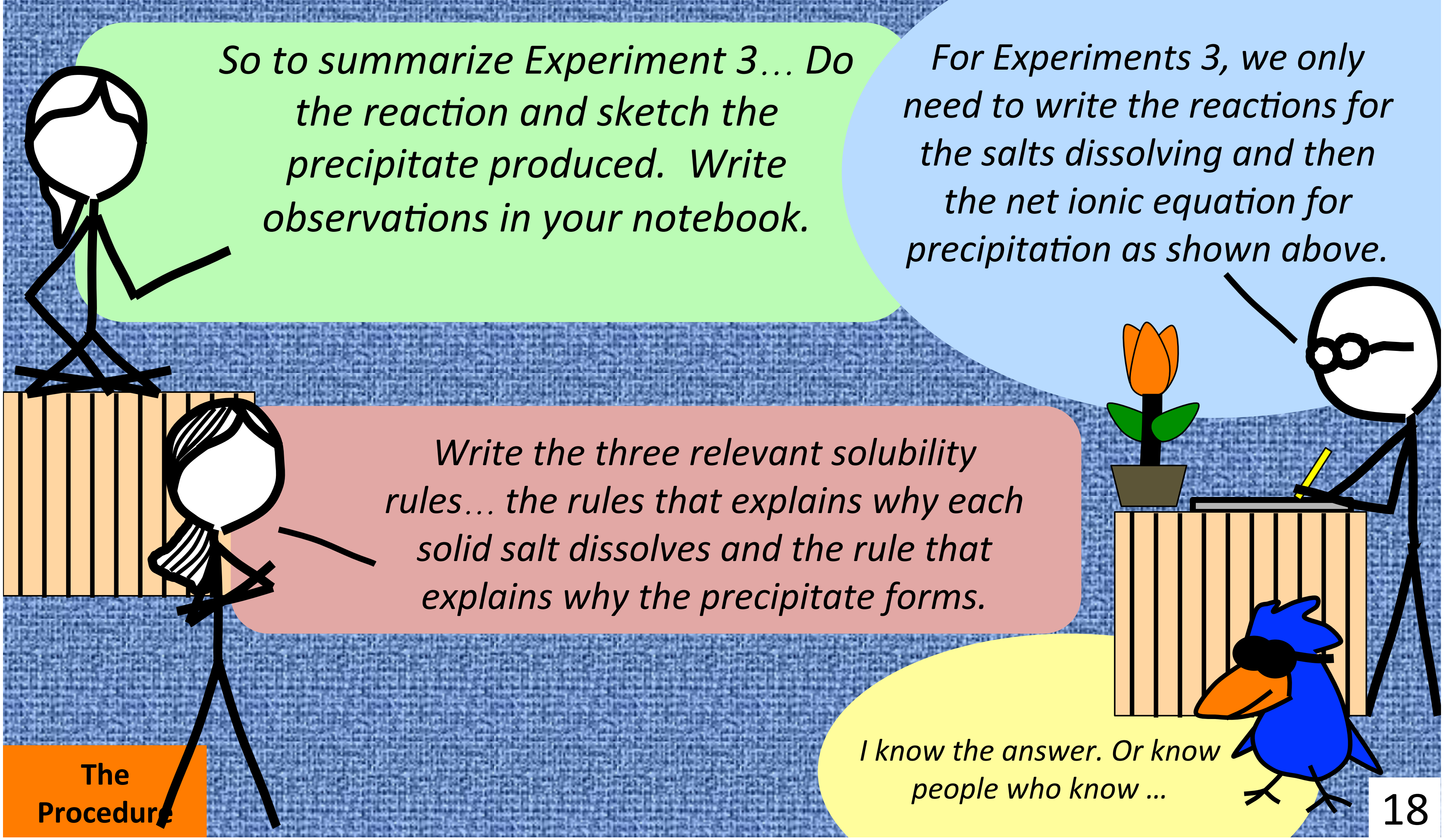
$Cu_3(PO_4)_2(s) + 2\ NaHSO_4(aq) + Na_2SO_4(aq)$

Not exactly pretty.

You may wonder, why didn't we just use Na_3PO_4 instead of Na_2HPO_4? It turns out that $Na_3PO_4(aq)$ forms hydroxides, OH^- in water like this: $PO_4^{3-}(aq) + H_2O(l) \rightarrow HPO_4^{2-}(aq) + OH^-(aq)$. And then the hydroxides form copper(II) hydroxide precipitate, $Cu(OH)_2(s)$! We'll learn a lot more about acid and basic behavior of salts next semester. But for now, we use Na_2HPO_4 because it doesn't have that problem.

3. Watching and writing precipitation reactions

$$3\ Cu^{2+}(aq) + 2\ HPO_4^{-}(aq) \rightarrow Cu_3(PO_4)_2(s) + 2\ H^{+}(aq)$$



3. Watching and writing precipitation reactions

Experiment 1. $AgNO_3(s) + NaCl(s) \rightarrow$

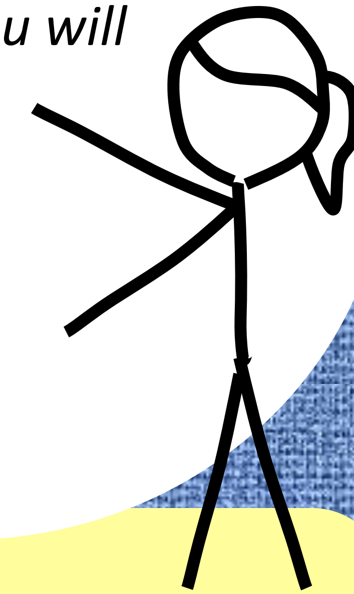
Experiment 2. $AgNO_3(s) + KI(s) \rightarrow$

Experiment 3. $CuSO_4{\cdot}5\,H_2O(s) + Na_2HPO_4(s) \rightarrow$

Experiment 4. $CuSO_4{\cdot}5\,H_2O(s) + NaCl(s) \rightarrow$

Experiment 5. $FeSO_4{\cdot}7\,H_2O(s) + NaHCO_3(s) \rightarrow$

These are the five experiments you will try today.



One of these is a "no reaction". Ooops I've said too much. When that happens we just write "No reaction". There is no net ionic equation or overall equation.

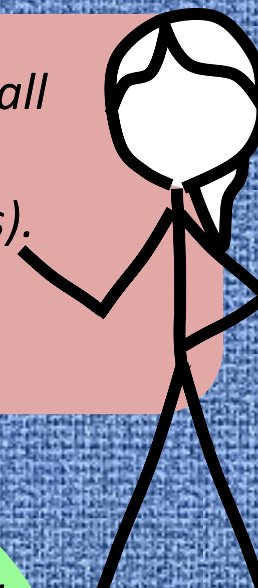
Pssst… It's Experiment 4. But why?

The Procedure

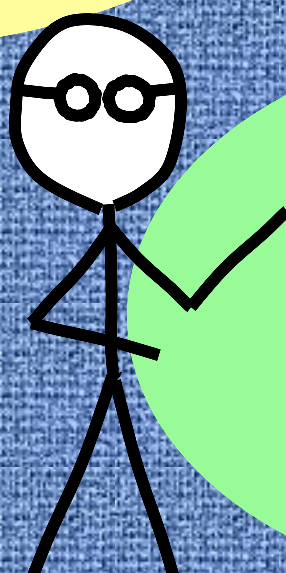
3. Watching and writing precipitation reactions

Experiment 5. $FeSO_4 \cdot 7\ H_2O(s) + NaHCO_3(s) \rightarrow$

Experiment 5 features iron(II) sulfate heptahydrate and sodium hydrogen carbonate (or you may call it sodium bicarbonate)



Start by writing the overall and ionic equation for dissolving $FeSO_4 \cdot 7\ H_2O(s)$. See Slide 14 for help.



Then do the same for $NaHCO_3(s)$. This makes just two ions, one of them is $Na^+(aq)$. See how we did it for $Na_2HPO_4(s)$ on Slide 15.

The Procedure

3. Watching and writing precipitation reactions

Experiment 5. $FeSO_4 \cdot 7\ H_2O(s) + NaHCO_3(s) \rightarrow$

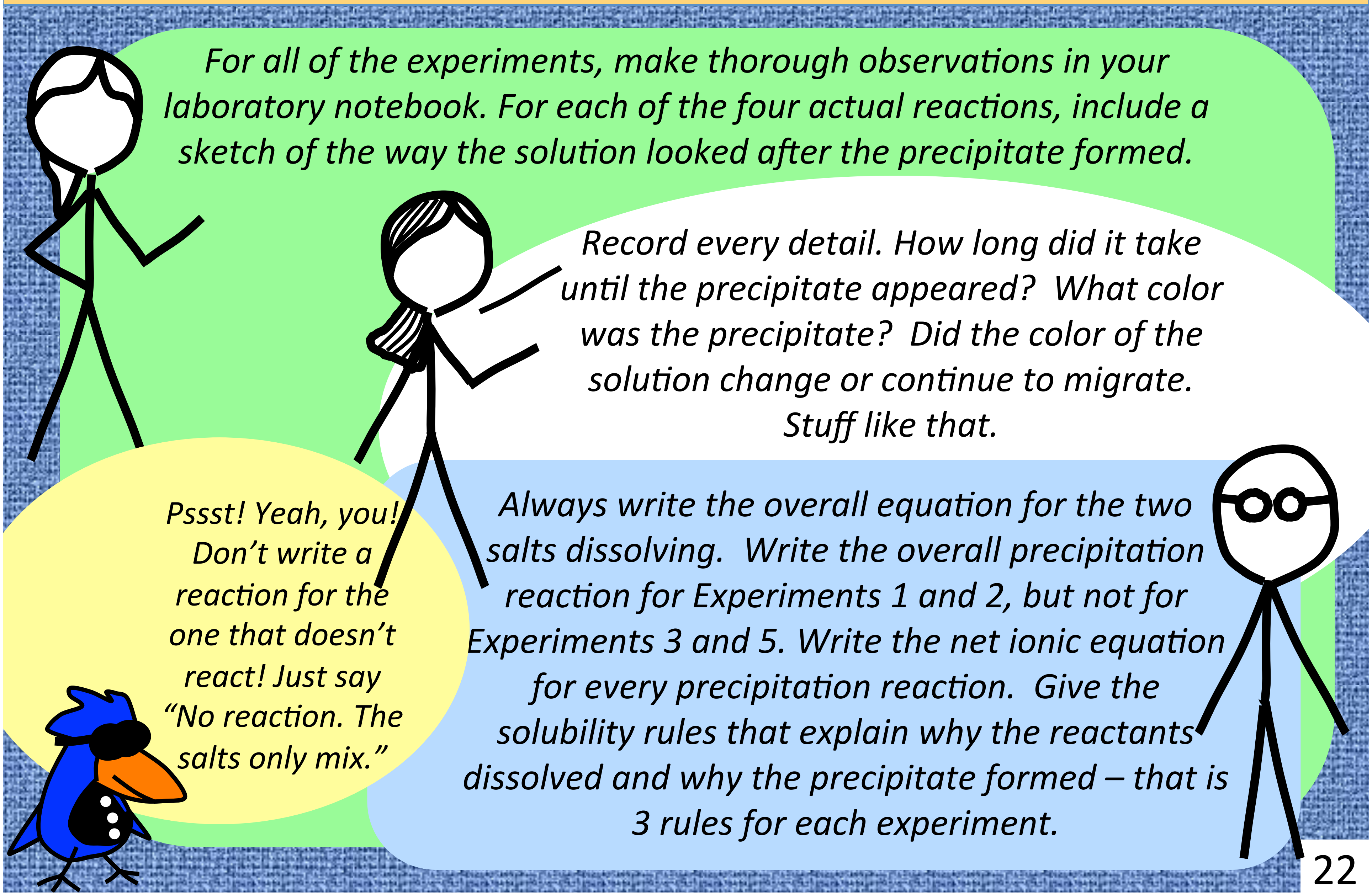
Remember how $HPO_4^-(aq)$ follows the same solubility rule as $PO_4^{3-}(aq)$? Well, $HCO_3^-(aq)$ follows the same solubility rule as $CO_3^{2-}(aq)$. Now you can write the net ionic equation between $Fe^{2+}(aq)$ and $HCO_3^-(aq)$. See Slide 16 to see how we did it for Experiment 3.

Oo! We are testing you!

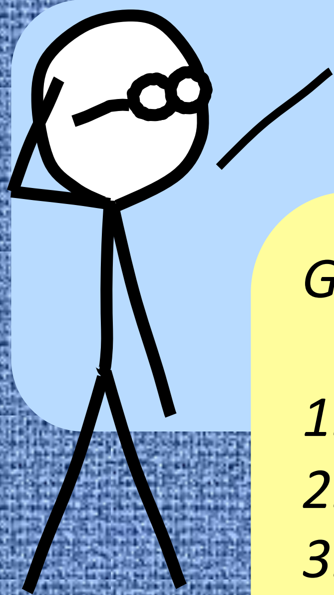
Then write the three relevant solubility rules… the rule for why $FeSO_4 \cdot 7\ H_2O(s)$ dissolves, the rule for why *$NaHCO_3(s)$ dissolves and finally the rule that explains the precipitate forms.*

The Procedure

3. Procedure Summary



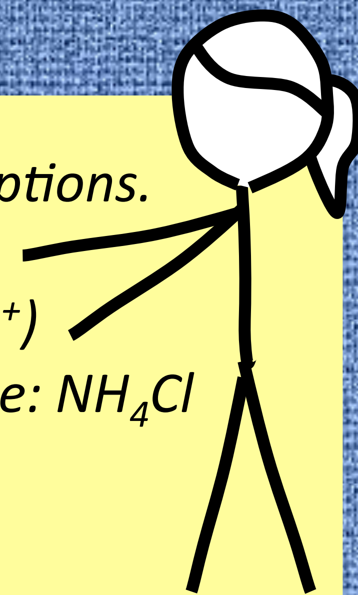
4. Discussion of Solubility Rules

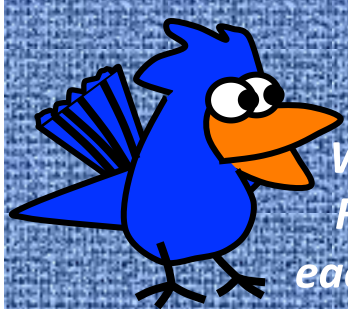


So… about those solubility rules...

Great. Some ions are always soluble with no exceptions.

1. *All Group I salts are soluble (Li^+, Na^+, K^+, Rb^+, Cs^+)*
2. *All ammonium salts, NH_4^+, are soluble. Example: NH_4Cl*
3. *All nitrate salts, NO_3^-, are soluble.*
4. *All perchlorate salts, ClO_4^-, are soluble.*
5. *All acetate salts, $C_2H_3O_2^-$, are soluble.*

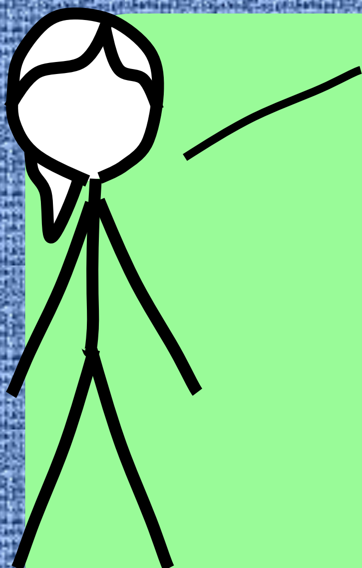




Which Solubility Rule applies for each of these salts?

A. Na_3PO_4	B. NH_4MnO_4
C. $Ca(NO_3)_2$	D. $AgC_2H_3O_2$
E. $LiBr$	E. NH_4NO_3

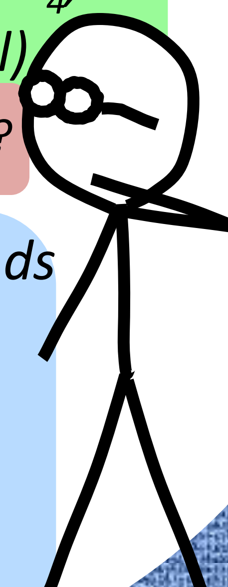
4. Discussion of Solubility Rules



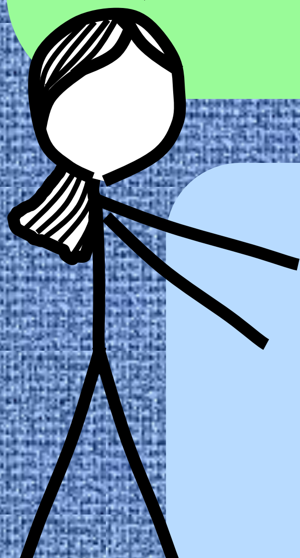
A few other anions are generally soluble with exceptions:

6. All chloride, bromide and iodide salts, Cl^-, Br^-, I^-, are soluble, except for salts of Ag^+, Pb^{2+}, and Hg_2^{2+}. For example, $PbBr_2$ and AgI and Hg_2Cl_2 are insoluble. In all, there are nine insoluble salts from this rule.

7. All sulfate salts, SO_4^{2-}, are soluble, except for $BaSO_4$, $PbSO_4$, and Hg_2SO_4 (Three insoluble exceptions in all).



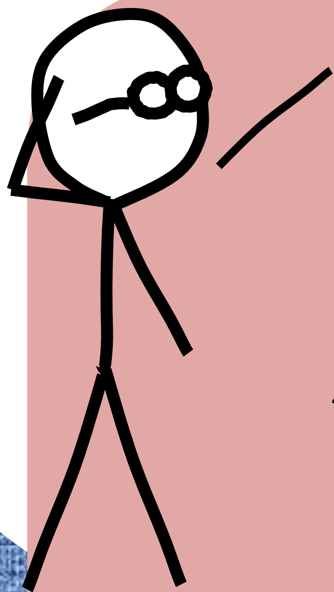
So Ag_2SO_4 is soluble?



*Now for the four anions that form **insoluble** compounds – unless the cations are Group I or ammonium:*

*8. Salts of CO_3^{2-}, S^{2-}, PO_4^{3-}, and OH^-, are **insoluble** (carbonates, sulfides, phosphates, hydroxides), except for cations are Group I or ammonium.*

4. Discussion of Solubility Rules

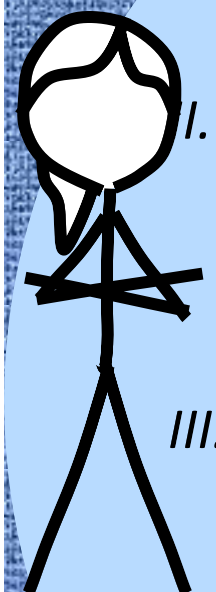


A little help please… What rule applies?

$PbCl_2$	$Ni(C_2H_3O_2)_2$
Ag_2SO_4	$FeBr_2$
$(NH_4)S$	$BaSO_4$
$Fe_3(PO_4)_2$	$CuSO_4$
KOH	$AgClO_4$

I'll do the first one – All chlorides are soluble except $PbCl_2$, Hg_2Cl_2 and $AgCl$.

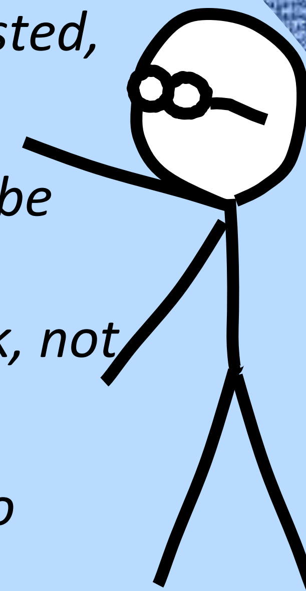
5. Lab today



I. *Wear your safety glasses today. Special clothing suggested, but not required today. (No acids, nothing nasty.)*

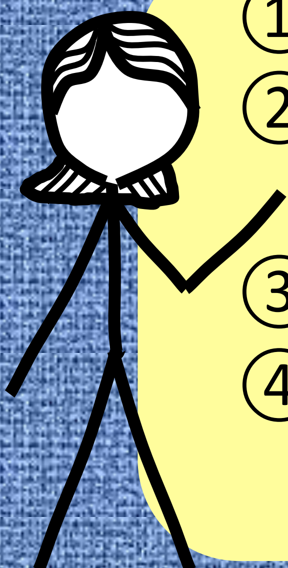
II. *Follow the procedures as written. The experiments will be done on the plastic sheet covered copy at your station. Record observations and drawings in your lab notebook, not on your procedure page.*

III. *The cover sheet summarizes everything that you need to include with your report. There is an emphasis on observations and balanced reactions, including ionic and net ionic when appropriate. Also Solubility Rules.*

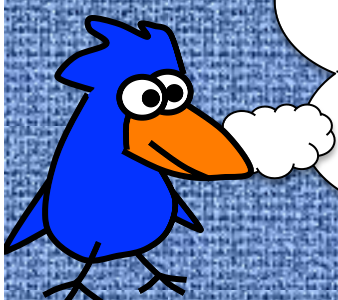


So this is embarrassing… I guess I didn't need the umbrella… but there were puddles. Hmm?

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. Turn in lab report ***today*** or ***before*** the start of class.
4. Master the Mohr pipet before you leave today!



You will be done with plenty of time left. Next week we will be using a Mohr pipet and a volumetric flask. There is a station in lab where you can learn about the Mohr pipet – a tricky tricky little device. A TA will show you how to use it properly.

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.*

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

Credit for the idea of microscale precipitation goes to Bob Worley of CLEAPSS (UK)