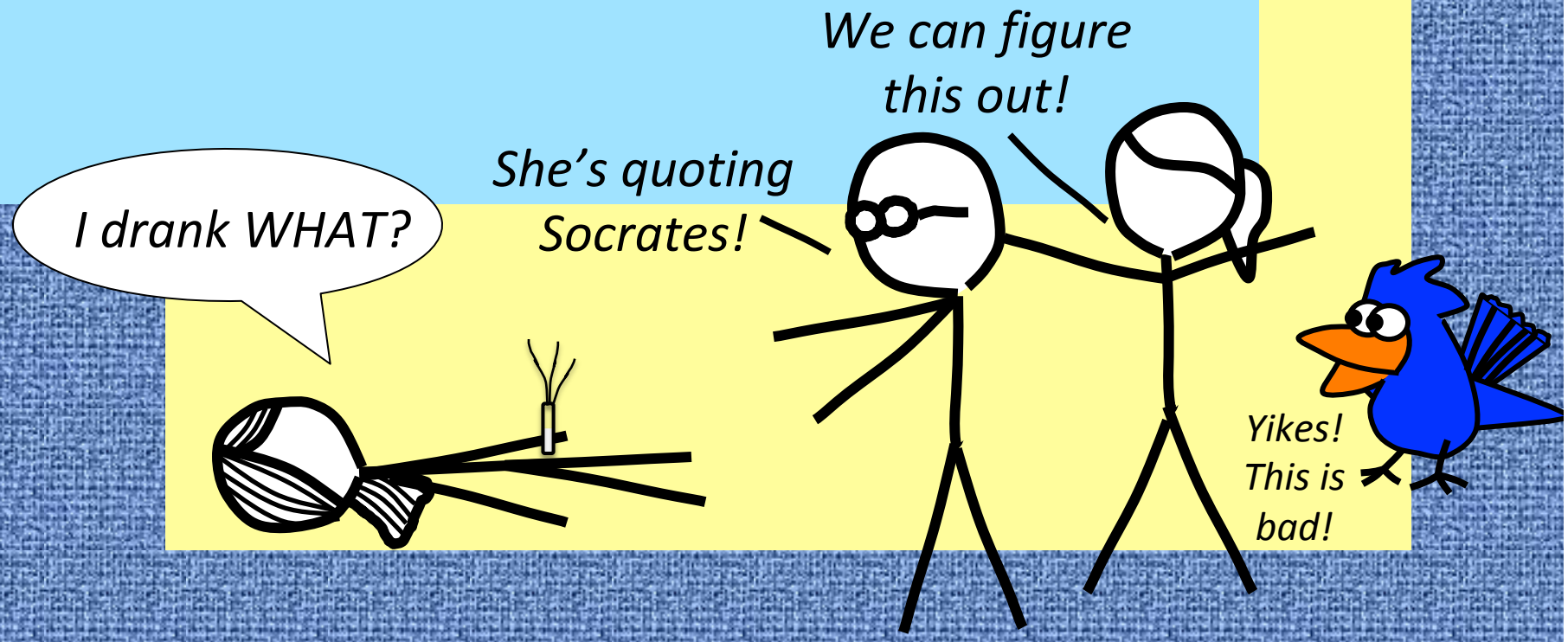
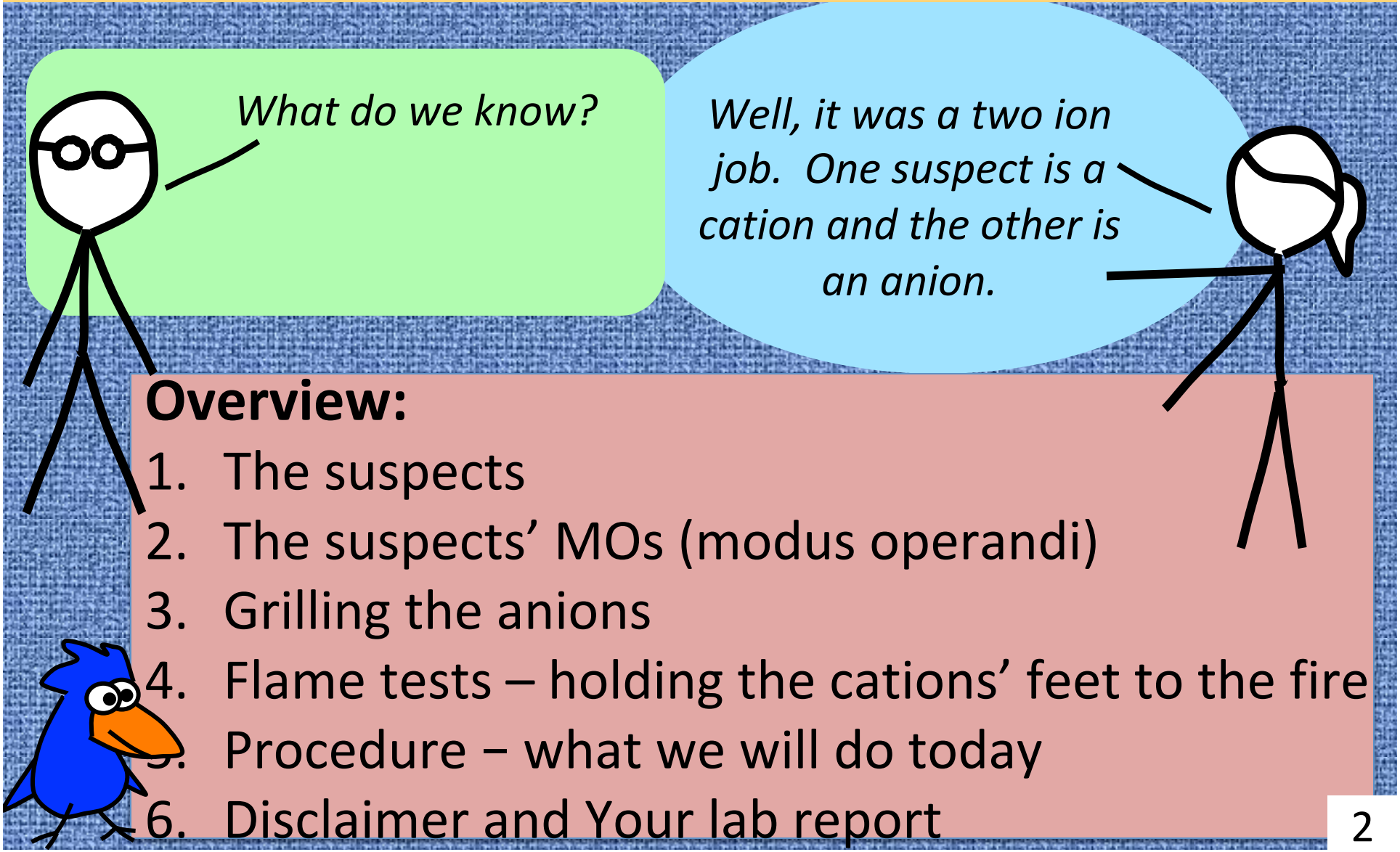
Experiment 2
3 September 2019
The Ion Detective Lab!



Objectives: Use detective skills to identify the cation and the anion in a solution.



Overview:

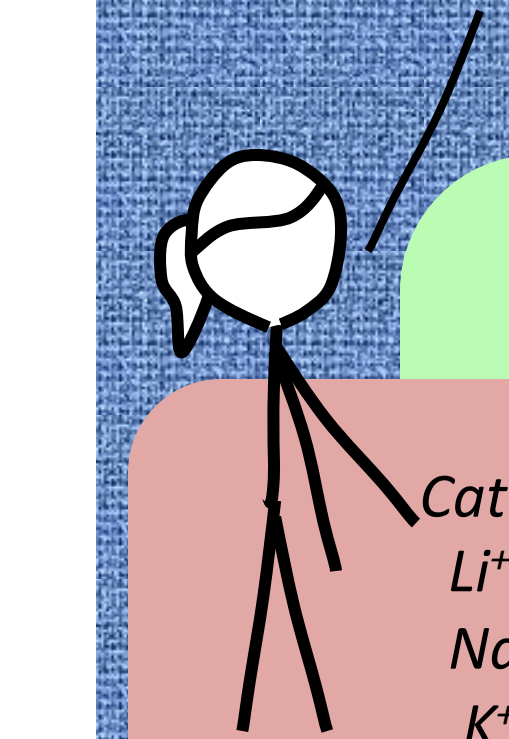
1. The suspects
2. The suspects' MOs (modus operandi)
3. Grilling the anions
4. Flame tests – holding the cations' feet to the fire
5. Procedure – what we will do today
6. Disclaimer and Your lab report

1. The suspects

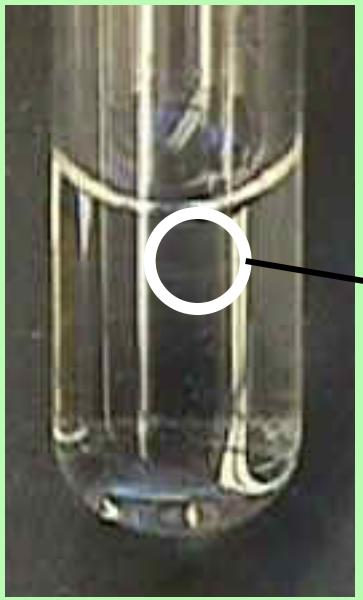
There are five possible cations: lithium ion, sodium ion, potassium ion barium ion and ammonium.

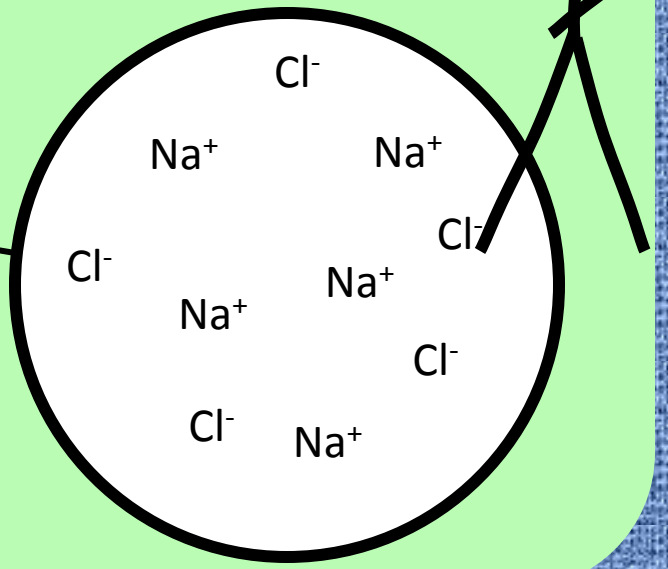
And five possible anions: sulfate, carbonate, chloride, iodide and acetate

Here is one of the 25 possible combinations.



Cations:	Anions:
Li^+	SO_4^{2-}
Na^+	CO_3^{2-}
K^+	Cl^-
Ba^{2+}	I^-
NH_4^+	$C_2H_3O_2^-$

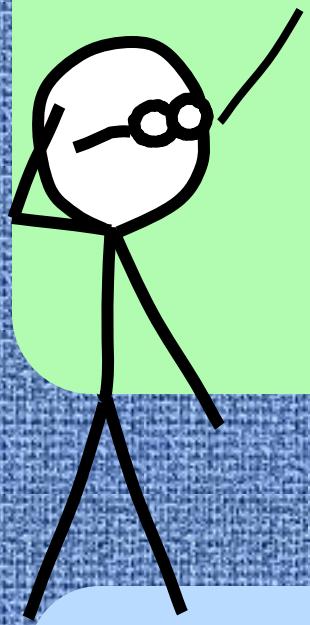




Info for Introduction

Photo credit http://dl.clackamas.edu/ch105/lesson3homogeneous_mixtures.html

2. The suspects' MOs – Sulfates

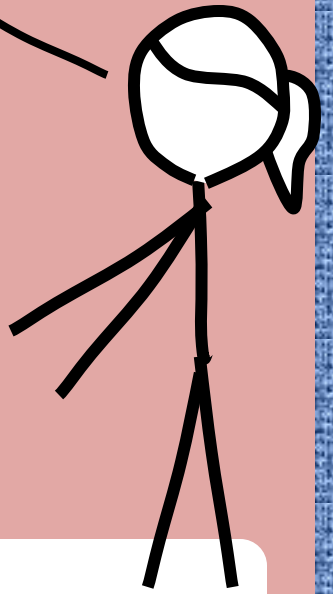


What do we know about the anions, say sulfate for example?

Sulfates are everywhere in our lives. They are in soap, shampoo, detergent and even toothpaste. Even the walls are almost entirely calcium sulfate. Sulfates are not very toxic.

When a precipitates forms it looks like a cloud until it settles. Barium sulfate is white.

Sulfates form a precipitate when a little aqueous barium ion, Ba^{2+} is added. Here is the net ionic equation:

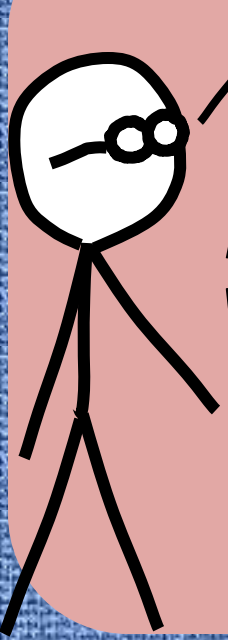


$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

Info for Procedure

Photo: http://igcsetuition.blogspot.com/2012/09/salts-preparing-insoluble-salts-by.html

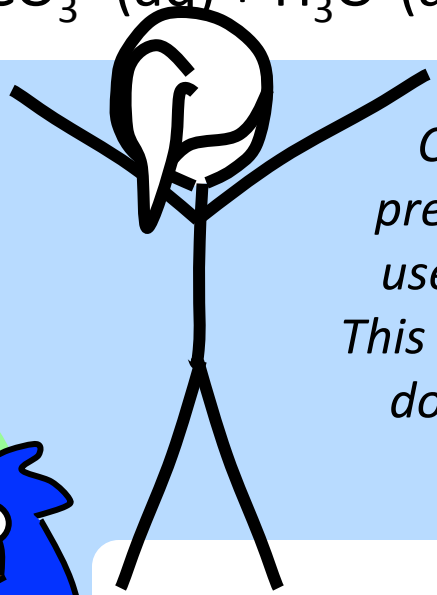
2. The suspects' MOs – Carbonates



Carbonates are also everywhere in our lives. They are in antacids, baking powder, sea shells, sea water, chalk and so on. Carbonates are part of the carbon cycle in nature. Carbonates are normally not toxic.

Carbonates are confirmed by adding acid and seeing bubbles of carbon dioxide. This is a definitive confirmation test for carbonate – from short list of possible anions. This means you can trust the results.

$$CO_3^{2-}(aq) + H_3O^+(aq) \rightarrow CO_2(g) + 2H_2O(l)$$



Carbonates also form a precipitate with barium ion used in the test for sulfate. This can be confusing. Sulfates do not make bubbles with acid, however.

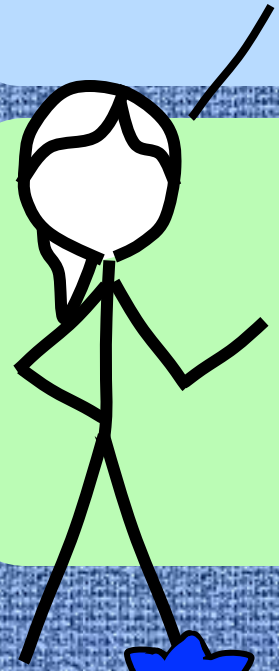
$$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$$

Note: When a test result leads to a result that is misleading, such as adding barium ion to test for sulfate and getting a precipitate with carbonate – it is called a ***false positive*** *for sulfate.*

Info for Procedure

2. The suspects' MOs – Chlorides and Iodides

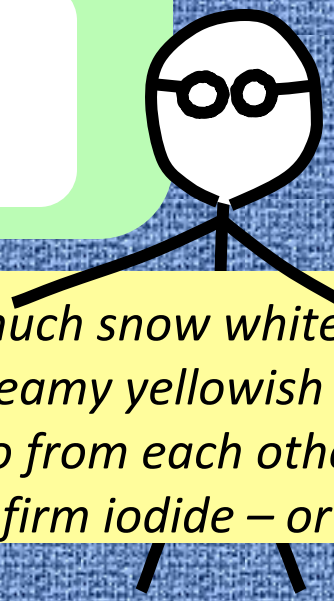
Chlorides are ubiquitous in our lives mostly in the form of sodium chloride. Chloride is an important electrolyte in our blood and helps control net water flow into and out of cells. Iodide is a micronutrient essential for proper thyroid function. Too much or too little of each is bad.



The test for chloride and iodide starts out the same. Both form precipitates with silver ion.

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

$$I^-(aq) + Ag^+(aq) \rightarrow AgI(s)$$

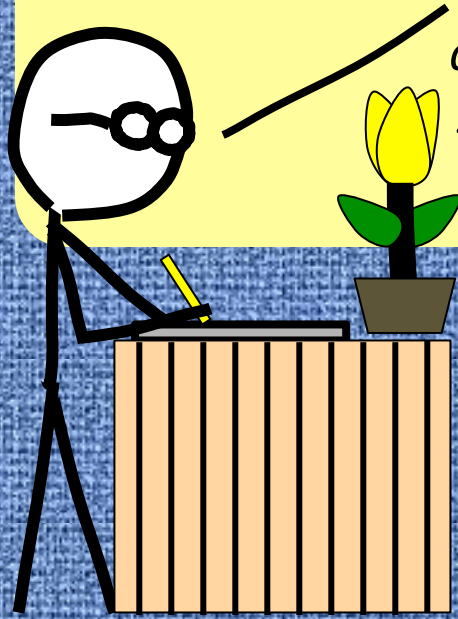


So silver chloride is pretty much snow white… and silver iodide is a little bit creamy yellowish – not enough to distinguish the two from each other… We need one more test to confirm iodide – or not.

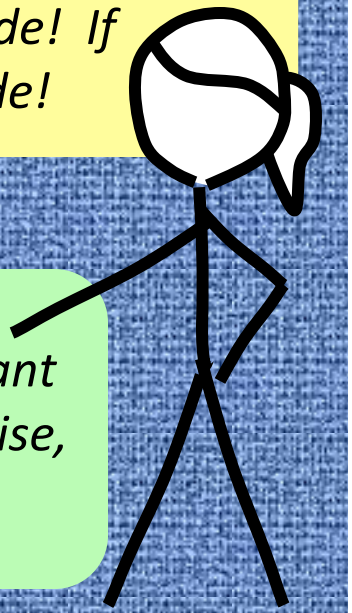
Just between you and me… I think iodide has waaay too many vowels.

Info fo
Procedure

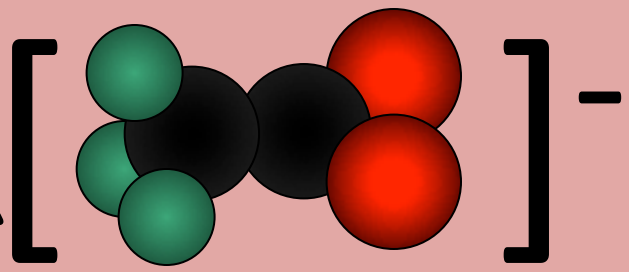
2. The suspects' MOs – Chlorides and Iodides



And that test would be the iodide test! We add a little acid, a little starch, and a little hydrogen peroxide to our sample and if we get a blue solution, we have iodide! If the solution does not turn blue, we have chloride!



The equations are in the lab manual if you want to know more about the iodide test… Otherwise, it's on to the last anion test: Acetate!

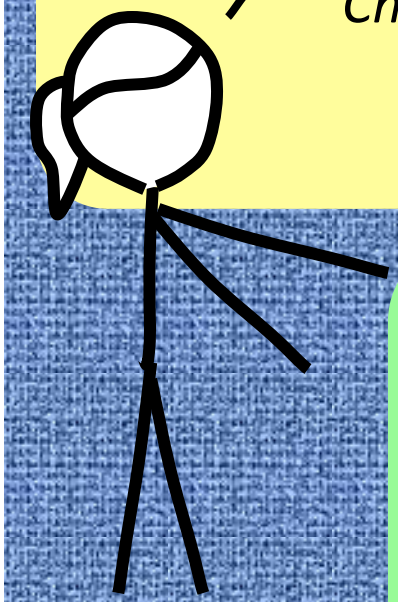


This is the acetate ion. People write it as CH_3COO^- or $CH_3CO_2^-$ or $C_2H_3O_2^-$. Mostly the last one in Gen Chem.

Info for Procedure

2. The suspects' MOs – Acetates

The acetate test does not involve a precipitation because of a solubility rule we will learn in Chapter 4: "All acetates are soluble". Instead…



…we add ~2 mL (40 drops) of 3 M $H_2SO_4(aq)$ to the sample that may contain the acetate ion. Mix thoroughly and see if it smells like vinegar – another name for dilute acetic acid, $HC_2H_3O_2$. A vinegar-like smell means we have acetate.

$$C_2H_3O_2^-(aq) + H_3O^+(aq) \rightarrow HC_2H_3O_2(aq) + H_2O(l)$$

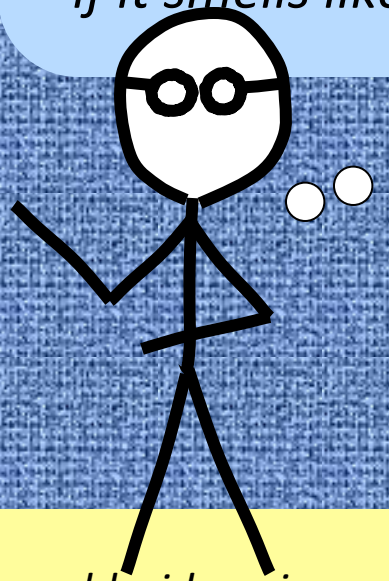
Info for Procedure

2. The suspects' MOs – Ammonium

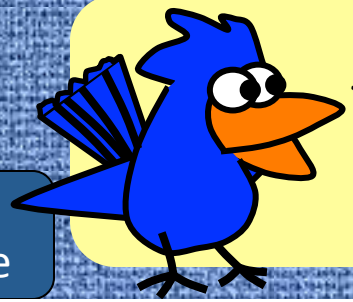
That does it for the anions. Only one cation requires a chemical test and all the others are done by flame test. We detect the ammonium ion by adding hydroxide ion. The reaction is

$$NH_4^+(aq) + OH^-(aq) \rightarrow NH_3(aq) + H_2O(l)$$

Add ~1 mL (20 drops) of 6 M NaOH(aq) to the sample that may contain the ammonium ion. Mix thoroughly and see if it smells like ammonia.



Entrust your lab partner to smell this stuff too.



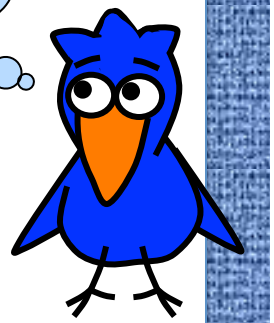
So a sodium cation walks up to a chloride anion and says, "Hey, you stole my electron!" The chloride looks perplexed and says, "What? Are you sure?" The sodium says, "Yes! I'm positive!"

Info for Procedure

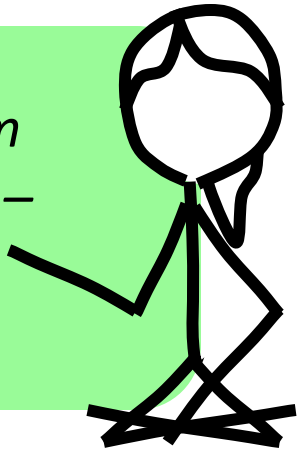
3. Grilling the ions by precipitation

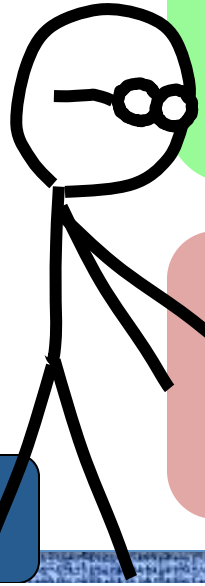
Adding a few drops of the testing solution doesn't always give an immediate result. This happens when the stuff being added is less dense than the solution being tested.

Wait! What's she doing here? I thought she was our victim. Plot line flaw!



Solutions do not mix very fast unless you help them to mix, by shaking them gently without splashing anything out – side to side shaking is better than up and down shaking.



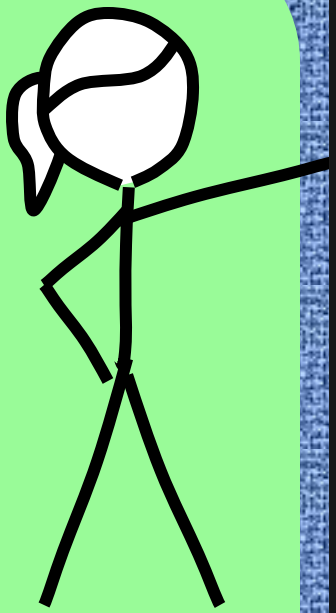


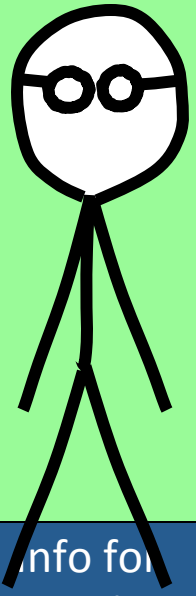
After adding one solution to another, there may be an interface that looks a little oily – this is not a precipitate! You need to mix it.

Info for Procedure

4. Flame tests – holding the cations' feet to the fire

Here are some flame test results for common metal cations. (Barium ion is a green-yellow.)



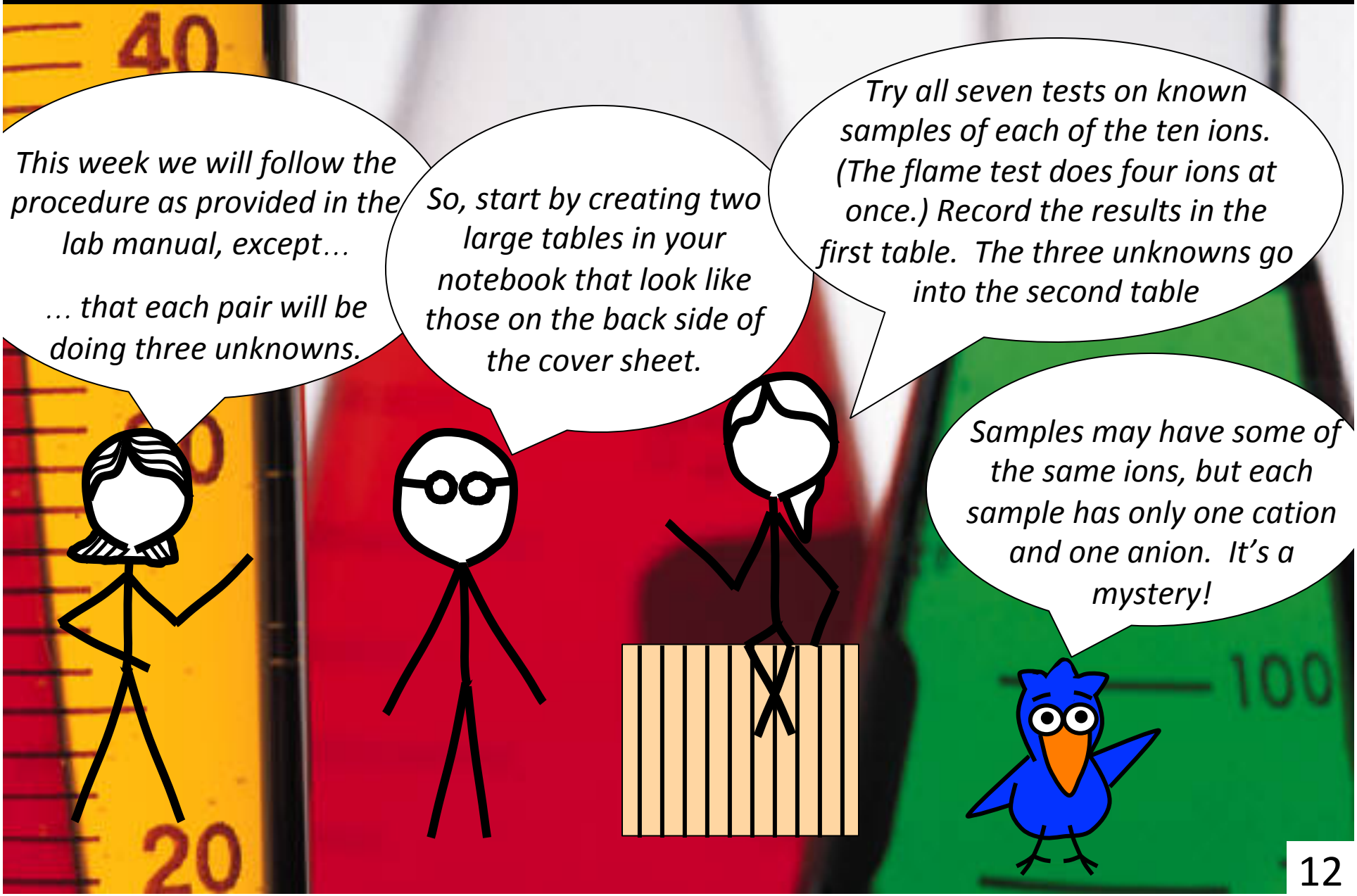


The color lasts just a split second. After the liquid is gone, all you are seeing is the metal ions in the spatula – iron or chromium..

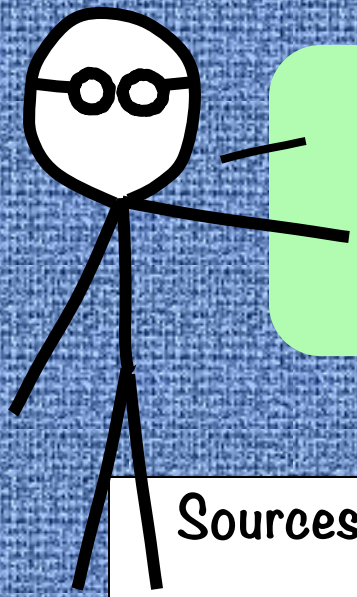
https://socratic.org/questions/why-are-chlorides-used-in-flame-test

Info for Procedure

5. Procedure: What we will do today



6. Your lab report.

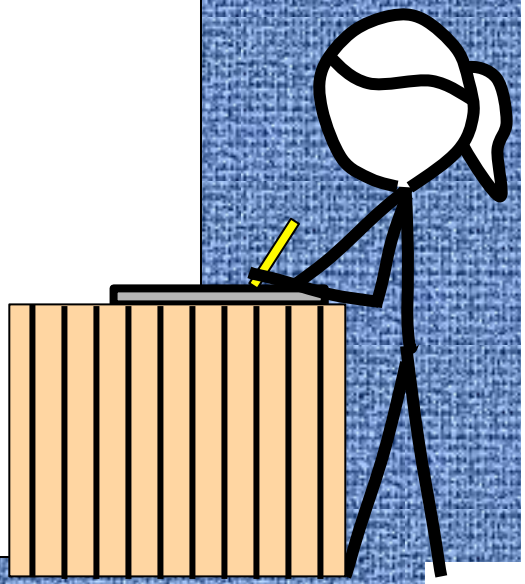


This is a good experiment to talk about sources of error. Think of all the things that could go wrong! Which tests were the most dodgy?

The carbonate test seems pretty solid. I mean bubbles don't lie...

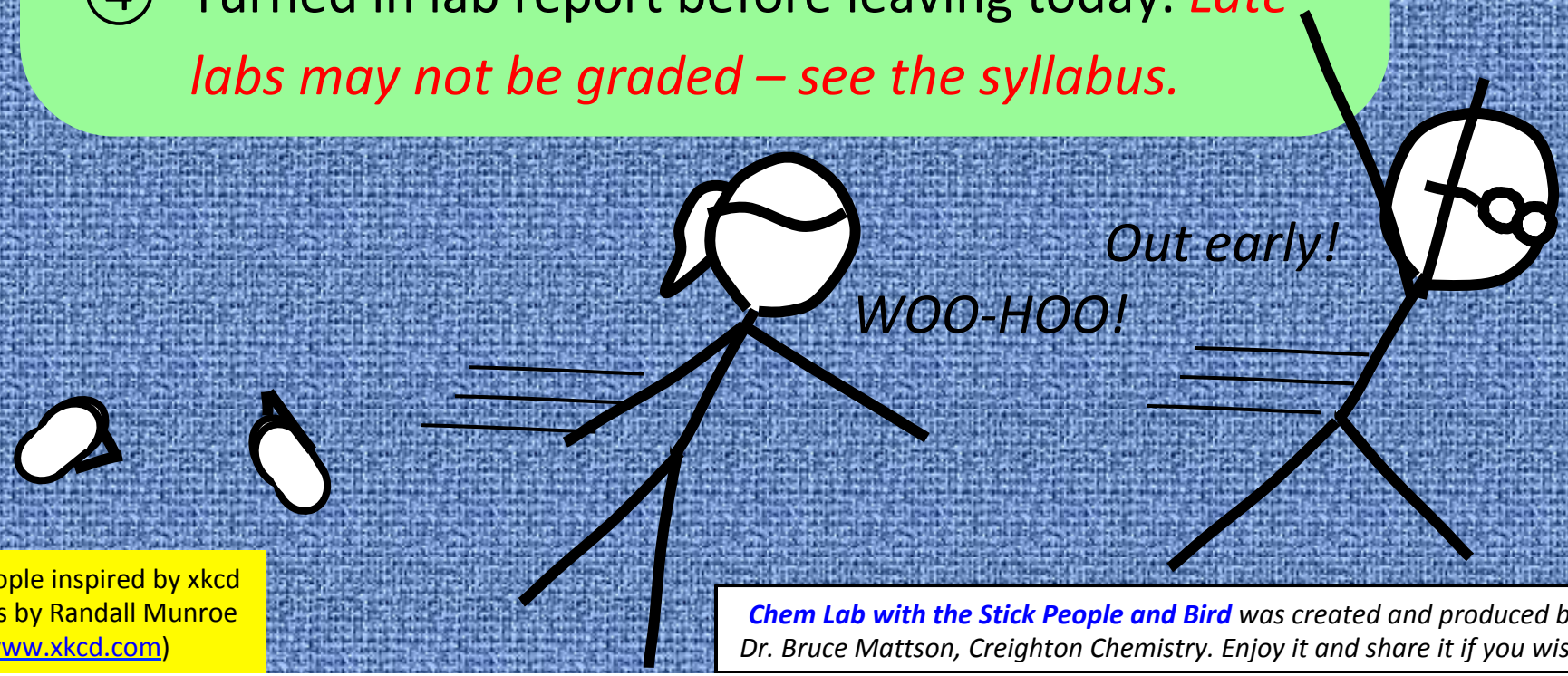
Sources of error.

We had the most trouble with the flame test with some of our solutions. One was clearly sodium, but the others were more faint and we are not completely sure we got them right. Some of the chemical tests were a bit tricky, too. The ammonia test and the acetate test relied on smells that were not easy to detect. Not properly mixing the chemicals would lead to inconclusive results, but we mixed solutions as directed, so we don't think that was an issue for us. Another...



6. Your lab report.

① First, the cover page with TA initials.
② Next, the trimmed copy pages from your lab notebook stapled together.
③ There is no on-line data entry with this lab
④ Turned in lab report before leaving today. *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.*

6. Disclaimer.

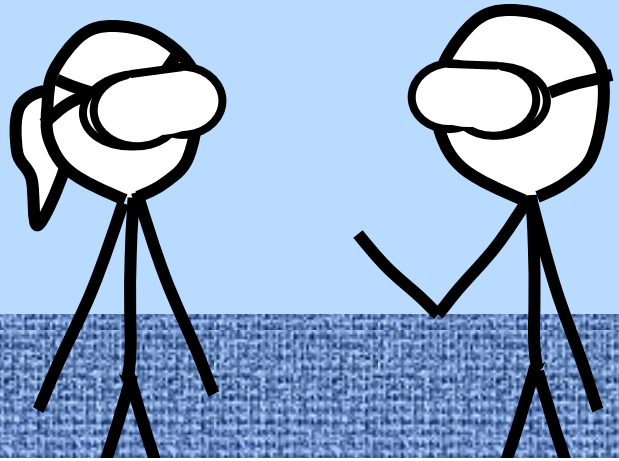
① The people and events depicted in this presentation are entirely fictional.

② No stick people were hurt in the production of this presentation.

③ Never drink anything you find in the lab.

④ Wear your safety glasses today.

⑤ And we need dress-for-a-mess clothing today.



Next week: We will need to dress for a mess.