The 14 Bottle Problem

Background

Considering the amount of chemistry you have been exposed to in the past year and in your first-year course, you might be expected to have some passing familiarity with common chemical behaviors, appearances, as well as physical and chemical properties. You have also had the opportunity to examine a variety of analytical methods for determining the presence--or absence--of substances in a mixture. It is now time to close *this* circle (oh, yes, there is more chemistry out there!) with a final exercise that will allow you to use your background and skills in solving a puzzle of sorts.

The Experiment

Working with another student you are to determine the identity of 14 aqueous solutions containing relatively common laboratory chemicals. Each bottle contains only one compound (other than the water), and each bottle contains a different *compound* (no duplicates--although some anions repeat).

The following non-locker materials will be provided:

- flame test loop
- 6 M HCl (for cleaning loop)
- 24-well plate
- 96-well plate
- neutral litmus paper
- 14 bottles of unknown solutions

The Chemicals

The list below contains all of the possible anions, cations and molecules that may be found in the bottles [in no particular order].

Cations	Anions	Molecules
Ba^{2+}	NO_3^-	NH_3
Sr^{2+}	SO_4^{2-}	
Li^+	Cl^-	
Zn^{2+}	OH^-	
Co^{2+}	CO_3^{2-}	
Mg^{2+}	SCN^-	
Na^+		
Al^{3+}		
Cu^{2+}		
Fe^{3+}		
K^+		
H^+		
Ag^+		

Since all solutions are unknowns no further information can be given. Standard laboratory caution should be exercised when handling the solutions.

Technique Discussion

You will be provided with 30 mL samples of each solution. You will not be allowed refills so be sure to conduct your testing wisely.

You must turn in individual work-in-progress on a daily basis just as you would for any other experiment.

Hints: Don't assume much. Be on the lookout for the obvious. Have fun!

The Report

Your conclusion to this experiment should include (along with the identity of each solution) a balanced net-ionic equation for each *meaningful* observation [this would not include flame tests but would, for example, include a rationalization for an acidic litmus test for a salt].

Adapted from: How to Make the N-Bottle Problem More Rigorous, J.Chem Ed., vol.70, No.10, p.850-851, Dennis P. Ryan and Ronald E. Strothkamp