The Clandestine Lab: A Qualitative Analysis Experiment

You have been selected as the chemistry expert on a team that will travel deep into remote areas to identify and clean up clandestine laboratories involved in the production of illicit substances. Because your team must travel quickly and without excess baggage, you will be expected to identify the solutions in these labs without using any instrumentation or other reagents.

Fortunately, all of the laboratories have been set up by the same illicit organization, and another team from your organization has "obtained" a list of the solutions present at the labs. Unfortunately, all of the lab workers have been instructed to not put labels on anything in the labs in case of a government raid.

The solutions available in all of the labs are: $Ni(NO_3)_2(aq)$, $Pb(NO_3)_2(aq)$, $Na_2CO_3(aq)$, $CuSO_4(aq)$, $HCl(aq)$, $NH_3(aq)$, $Fe(NO_3)_3(aq, \mathcal{N})$, $NaOH(aq)$, $CaCl_2(aq)$, $H_2SO_4(aq)$, $HNO_3(aq)$, $AgC_2H_3O_2(aq)$, $NaI(aq)$

$\mathcal{N}$ – to keep this substance stable, it is dissolved in nitric acid

As part of your training, you will be provided authentic, labeled samples of all these solutions and will spend a week observing them and testing different combinations of them. To make your job easier once you are in the field, it would be good to develop a systematic approach to your tests, and the best way to organize your data and observations is with a grid/table that allows you to observe and mix all possible combinations. If you were only testing 4 substances, your table might look like the one below:

Table 1: Analysis of 4 Unknown Solutions:

	# 1	# 2	# 3	# 4
# 1	Colorless solution with a strong odor	No reaction	Thick red-brown precipitate forms.	Mixture becomes warm, some smoke seems to form
# 2	No reaction	Colorless, odorless solution	Orange precipitate forms.	Mixture forms a gas that bubbles out of solution
# 3	Thick red-brown precipitate forms.	Orange precipitate forms.	Yellow solution, very slight odor	Solution becomes much more yellow after addition.
# 4	Mixture becomes warm, some smoke seems to form	Mixture forms a gas that bubbles out of solution	No reaction? Maybe a little more yellow?	Colorless solution, moderate odor

In some cases, the order of addition can lead to slightly different observations, so all boxes should be tested by starting with 10 drops of the substance listed in the first column and adding 5 drops of the substance listed across the first row. The diagonal blocks (# 1 with # 1, # 2 with # 2, etc.) are used for observations of the unmixed samples.

Before lab:
Group the list of substances into categories based upon the reactions in which they are likely to be involved, such as acids and bases, gas-forming substances, likely precipitates, etc.

Predict some of the reactions that might take place and any observations you might make. You may assume that all reactions (at least initially) will be metathesis/exchange reactions.

After the first week of training, you will be sent to the field and will have to draw upon your experience and observations to identify the contents of unlabeled bottles.

Solubility Rules

1. All common compounds of Group I (the alkali metals), and ammonium ions are soluble.
2. All nitrates, acetates, and chlorates are soluble.
3. All binary compounds of the halogens (other than fluorides) with metals are soluble, except those of Ag, Hg (I), and Pb(II). (Pb halides are soluble in hot water.)
4. All sulfates are soluble, except those of barium, strontium, calcium, lead, silver, and mercury (I).
5. Carbonates, hydroxides, oxides, silicates, and phosphates are insoluble, except those in Rule 1.
6. Sulfides are insoluble except for calcium, barium, strontium, magnesium, sodium, potassium, and ammonium.

Also note:

1. Oxidizing agents (including oxoanions such as the nitrate ion, NO_3^-) generate strongly colored iodine and bromine in acidic conditions (usually) from iodides and bromides.
2. Reducing agents react with iodine and bromine to produce colorless iodides and bromides.
3. Carbonates, sulfites and sulfides react with mineral acids (such as HCl and HNO_3) to produce gaseous products (effervescence), carbon dioxide, sulfur dioxide and hydrogen sulfide respectively.
4. Strong acids react with strong bases to produce water, salt and heat.

Safety Notes:

You will be working with a wide variety of substances in this experiment, all of which have unique safety issues and hazards. Acids and bases are corrosive, a number of the substances have strong odors, and some of these substances can stain skin and clothing. We are working with relatively safe amounts and concentrations, but as always, be sure you handle all of these substances with the respect they deserve. Do not touch any of these solutions. When smelling, carefully "waft" the vapors toward your nose. If you have questions or concerns about any of the substances we are using in this (or any) experiment, do not hesitate to ask questions.