Name: _____ Section: _____

Experiment #7: Qualitative Analysis of Various Reagents

The Ten Bottle Mystery

There are two broad categories of problems in analytical chemistry: quantitative and qualitative analyses. Quantitative analysis deals with the determination of the amounts of species present in a sample. Qualitative analysis involves establishing whether given species are present in detectable amounts in a sample. In the laboratory, qualitative analysis often tests for the presence of a possible component by adding a reagent that reacts with the component in a characteristic way.

You will be furnished with ten numbered bottles, each of which will contain a single substance. Prior to the experiment, you will be assigned either Set A or Set B (listed below) of unknowns. Your task is to find out which solution is in which bottle. You will do this by mixing small volumes of the solutions in test tubes and recording your observations. *NO ADDITIONAL REAGENTS OR ACID-BASE INDICATORS SUCH AS LITMUS PAPER ARE ALLOWED*. You are permitted, however, to use the odor and color of the different species and to use your reaction matrix (to be completed BEFORE LAB and discussed below) when identifying the various bottles.

Of the ten solutions, four are common laboratory reagents. They are 6 M HCl, 3 M H_2SO_4, 6 M NH_4OH (*i.e.* NH_3 *(aq)*), and 6 M NaOH. The other six are 0.1 M solutions of:

$Al(NO_3)_3$, $AgNO_3$, $Ca(NO_3)_2$, $Cu(NO_3)_2$, $Ni(NO_3)_2$, and $SnCl_4$

To determine which solution is in each bottle, you will need to know what happens when the various solutions are mixed. In some cases, nothing happens. This often happens when two solutions with similar cations are mixed. When one of the reagents is mixed with a different cation solution, you may get a precipitate, white or colored, and that precipitate may dissolve in excess reagent by complex-ion formation (a topic for Chemistry 1B). Furthermore, some solutions become very warm and/or produce a visible vapor.

You will not be able to solve your particular ten bottle mystery without doing some preliminary work. You need to know what to expect when any two of your ten solutions are mixed. You can find this out by consulting your chemistry textbook, solubility rules, referring to various reference works on qualitative analysis such as the *CRC Handbook of Chemistry and Physics*, and searching online. A convenient way to tabulate the information you obtain is to set up a matrix with ten columns and ten rows, one for each solution. At each intersection, write the products that you'd expect to find. For example, if a precipitate forms, you might write "P" along with the color. If heat is evolved, you might write an "H". If gas or smoke is formed, you might write "G" and "S", respectively. Since mixing solution A with B is the same as mixing B with A, not all 100 spaces in the 10-by-10 matrix need to be filled.

Because you are allowed to use the odor or color of a solution to identify it, the problem is somewhat simpler than it might first appear. In each set of ten solutions, you will probably be able to identify at least two solutions by odor and color tests. Knowing the identity of

those solutions, you can make mixtures with the other solutions in which one of the components is known. From the results obtained with those mixtures and the information in the matrix, you can identify other solutions. These can be used to identify still others, until the entire set of ten is finally identified.

Pre-lab Questions

1. Fill in the matrix below to show how various solutions react, as described in the procedure.

HCl	H_2SO_4	NaOH	NH_4OH	$Al(NO_3)_3$	$AgNO_3$	$Ca(NO_3)_2$	$Cu(NO_3)_2$	$Ni(NO_3)_2$	$SnCl_4$	
										HCl
										H_2SO_4
										NaOH
										NH_4OH
										$Al(NO_3)_3$
										$AgNO_3$
										$Ca(NO_3)_2$
										$Cu(NO_3)_2$
										$Ni(NO_3)_2$
										$SnCl_4$
										NOTES

Name: _____ Section: _____

2. Which solutions should you expect to identify by simple observations?

3. Outline the procedure you will follow in identifying the remaining solutions. Be specific about what to look for and what conclusions you expect to draw from your observations.

Name: _____ Section: _____

QUALITATIVE ANALYSIS Report Sheet

Final Identifications:

No. 1 _____ No. 6 _____

No. 2 _____ No. 7 _____

No. 3 _____ No. 8 _____

No. 4 _____ No. 9 _____

No. 5 _____ No. 10 _____

Use the next few pages to write balanced MOLECULAR, IONIC, and NET-IONIC equations for TEN of the reactions that occurred during this laboratory experiment. Make sure to include the physical states of all the products. These equations must be turned in along with this report sheet to receive full credit upon conclusion of the lab.

1. Molecular:

   Ionic:

   Net-ionic:

2. Molecular:

   Ionic:

   Net-ionic:

3. Molecular:

   Ionic:

   Net-ionic:

4. Molecular:

   Ionic:

   Net-ionic:

Name: _____ Section: _____

5. Molecular:

   Ionic:

   Net-ionic:

6. Molecular:

   Ionic:

   Net-ionic:

7. Molecular:

   Ionic:

   Net-ionic:

8. Molecular:

   Ionic:

   Net-ionic:

9. Molecular:

   Ionic:

   Net-ionic:

10. Molecular:

    Ionic:

    Net-ionic: