Investigation 5
What's in the Bottles?

Introduction

Among the basic problems which frequently confront a chemist is the analysis of materials to determine both the identity of the elements or groups of elements present in a given substance (*qualitative analysis*) and how much of each is present (*quantitative analysis*). In this investigation, we will focus only on the identification of substances. Chemists often must depend on the observation of the chemical properties of substances in order to make an identification, just as a detective often must depend on the observation of the behavior of individuals suspected of being involved in a crime. The chemist may look for clues concerning the identity of a substance by observations of pH, color, odor, viscosity, and the results of mixing two substances. Typical results might be evolution or absorption of heat, formation of an insoluble solid (*precipitate*), color of the precipitate, evolution of a gas, odor of the gas, and so on.

Suppose your team of chemical investigators is working for an environmental agency. You have been asked to identify the contents of several unlabeled bottles collected in the laboratory of a company that is not complying with standards of correctly labeling chemical supplies. The environmental agency wants your team to determine the contents of each bottle obtained from the laboratory and report your findings.

Goals

As you complete this investigation you will:

1. Observe chemical reactions arising from the mixing of solutions of different chemicals.
2. Use your observations to identify the contents of unlabeled bottles, based on the type of chemical reactions expected.
3. Recognize various classes of chemical reactions.
4. Report your findings in a scientific manner.

Materials

Set 1: $AgNO_3(aq)$, $Mn(NO_3)_2(aq)$, $Ba(NO_3)_2(aq)$, $HCl(aq)$, $NaOH(aq)$
Set 2: $Zn(NO_3)_2(aq)$, $Al(NO_3)_3(aq)$, $AgNO_3(aq)$, $NaOH(aq)$, $NH_3(aq)$
Set 3: $AgNO_3(aq)$, $Ba(NO_3)_2(aq)$, $HCl(aq)$, $H_2SO_4(aq)$, $NaOH(aq)$
Set 4: $AgNO_3(aq)$, $Pb(NO_3)_2(aq)$, $HCl(aq)$, $NH_3(aq)$, $H_2O(aq)$
Litmus paper, universal indicator, or pH meter
Spot-plate
Droppers
Thermometer or temperature probe
Other supplies by request

Getting Started

The purpose of the experiment is to identify the contents of each bottle, matching the bottle numbers or letters with the chemical species listed for your set. You will be assigned one of the four sets of unlabeled bottles previously listed. The sets might be given a unique letter, number, or color code. The bottles will be identified only by code numbers or letters assigned by the environmental firm. Your first task might be to identify the particular set you have been assigned. Because the environmental firm has limited resources, the only reagents you have available are the contents of the unlabeled bottles. However; you can make observations of the interactions among the contents of the bottles by mixing them with one another in drop-by-drop quantities. From an analysis of the observed results of interaction between the bottle contents, you should be able to identify each solution. If you feel that you need some external reagent to confirm your conclusions, consult your instructor and obtain permission first.

Keep in mind that all the unknown substances listed above dissociate in water. For example, when solid silver nitrate, $AgNO_3$, dissolves in water it produces Ag^+ and NO_3^- ions. However, some substances do not dissociate in water. You might consult a table of solubility rules in your text to determine which combinations of substances will give a solid precipitate.

You might consider using litmus paper to determine if your solutions are acids or bases. Defined simply, an acid is a substance that donates H^+ ions to solution when the substance is in water. A base is a substance that accepts H^+ ions. Chemists use pH as a measure of the acidity or basicity of a substance. A neutral solution has a pH of 7, an acid has a pH below 7, and a base has a pH above 7. You can use red and blue litmus paper to provide a simple qualitative way of determining if a solution is an acid or a base. Red litmus paper will turn blue in the presence of base and blue litmus paper will turn red in the presence of acid. If needed, consult your text for further information regarding acids and bases.

Report

The report must be typed and grammatically correct. It may be returned to you for corrections if it is not acceptable. Keep in mind the context for which you are completing this investigation. A discussion of the chemical reactions you observed and equations that represent those reactions must be embedded in an appropriate section of your report. You should also identify each chemical reaction according to its reaction class (single displacement, double displacement, and so on). Also, write net ionic equations and identify spectator ions when appropriate.

Caution:
While working in the laboratory wear your goggles at all times. You are working with strong acids and bases that can cause permanent damage to eyes and skin.