Purpose

In this experiment, the identity of six solutions of ionized inorganic solutes is established by observing reactions between pairs of the solutions.

Learning Objectives

Write net ionic equations for reactions that produce a precipitate or a gas.

Determine and write the chemical formula for an unknown solution.

Laboratory Skills

Make careful observations.

Introduction

This experiment will give you a chance to be a sort of chemical Sherlock Holmes —you will be given six bottles of UNKNOWN solutions, labeled only with a letter or number code, and you will IDENTIFY the solutions by their REACTIONS WITH EACH OTHER.

EVIDENCE for reaction when two solutions are mixed is based on observation of the following phenomena:

1. A precipitate (solid substance) is formed.
2. A gas is evolved from the solutions.
3. A color change is observed.
4. A characteristic odor is produced.

Each of these phenomena will be discussed briefly, with examples:

1. A precipitate is formed.

Very often, when solutions of IONIC SOLUTES are mixed, one of the four possible COMBINATIONS of the ions involved will have a very SMALL SOLUBILITY in water, and a PRECIPITATE of that substance will form (imparting a CLOUDINESS to the solution until the substance settles out completely). For example, if 0.1 M solutions of BARIUM NITRATE and SODIUM CARBONATE are mixed (each of these substances is fairly water SOLUBLE), a PRECIPITATE instantly forms, since one of the four possible combinations of ions, BARIUM CARBONATE, is of very LOW SOLUBILITY.

$$Ba(NO_3)_2 + Na_2CO_3 \rightarrow 2NaNO_3 + BaCO_3 \qquad \text{(total reaction)}$$

$$Ba^{2+} + CO_3^{2-} \rightarrow BaCO_3 \qquad \text{(net ionic form)}$$

You can PREDICT which combinations of ions are likely to produce precipitates by consulting the "Solubility Rules" listed in your textbook in Chapter 4.

2. A gas is evolved from the solutions.

Certain ions, such as CARBONATE and BICARBONATE, produce GASES when reacted with other ions (HYDROGEN ion, for example). Sometimes, the gas evolved can be IDENTIFIED by a characteristic odor [see also (4) below]; in other cases, the gas may have to be identified by other means.

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2 \qquad \text{(total reaction)}$$

$$CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2 \qquad \text{(net ionic form)}$$

3. A color change is observed.

The presence of certain ions can be confirmed by the addition of reagents that produce a COLOR CHANGE, which is CHARACTERISTIC of the ion under study; for example, AMMONIA, when added to a solution of COPPER(II) ION, produces a coordination complex of characteristic INTENSE BLUE color.

$$Cu^{2+} + 4NH_3 \rightarrow Cu(NH_3)_4^{2+}$$

pale blue dark blue

4. A characteristic odor is produced.

Certain ions, especially when acidified, produce gases with CHARACTERISTIC ODORS (the solution may have to be heated to release the dissolved gas). As you will see in the experiment synthesizing sodium thiosulfate pentahydrate, when the thiosulfate ion is acidified and the solution heated, SULFUR DIOXIDE gas, with its characteristic choking odor, is released.

$$S_2O_3^{2-} + 2H^+ \rightarrow H_2S_2O_3 \rightarrow H_2O + S + SO_2$$