5—Identification of Common Chemicals

Name: ______________________________________________
Date: ________________________________________________
Section: _____________________________________________

Objectives
• Develop a testing sequence that can be used to identify any of ten common household chemicals
• Use color, crystalline structure and solubility in water to distinguish 5 solid substances
• Use pH, precipitate formation, gas formation and odor to distinguish 5 solid substances and 5 liquid solutions
• Use your table of observations to identify an unknown solid and an unknown liquid

Pre-Laboratory Requirements
• Read chapter 4.3 in Silberberg
• Pre-lab questions (if required by your instructor)
• Laboratory notebook—prepared before lab (if required by your instructor)

Safety Notes
• Eye protection must be worn at all times.
• You will be working with solutions of several hazardous chemicals in this experiment (H₂SO₄, HCl, NaOH, AgNO₃). You should wear gloves when handling these solutions and avoid spilling them on your clothing. Use of a lab coat or lab apron is recommended.

Discussion

Everyone loves a mystery or a good detective story. We are fascinated by the challenge associated with associating observations to solve a puzzle. One reason for the popularity of the CSI television series is that the main characters are able to collect evidence to solve crimes. Much of the evidence used to solve these mysteries is collected from chemical tests, much like the tests you will perform in today’s experiment.

Observations, used with a process of deductive reasoning, are powerful tools for solving mysteries. In today’s experiment you will prepare a matrix of observations and properties that can be used to identify unknown substances. Your matrix will be limited to five solid substances and five liquid solutions because of time restrictions. The techniques that we develop in today’s experiment, however, are the same techniques used by hazmat crews in the fire department when they have to identify substances quickly. There is not time to send a substance to a laboratory for analysis in many emergency situations, and hazmat crews rely on a series of spots tests, precipitation reactions, and physical observations to make decisions about treating substances that might be spilled at the scene of an accident. When used in this manner, the matrix that you will be preparing today is converted to a flowchart that allows first responders to make decisions quickly.
A precipitate forms when two solutions are combined that produce a compound that is not soluble in water. A common precipitate reaction is the one between solutions of silver nitrate and sodium chloride. Although silver nitrate is soluble in water, the addition of a chloride ion to a solution of silver nitrate results in the formation of silver chloride. Silver chloride is not soluble in water and a white precipitate forms. This is called a precipitation reaction. Be sure to read section 4.3 in your textbook, pages 122-125, before beginning this experiment.

Many of your observations today will be based on precipitation reactions. The solubility rules, page 123 of your textbook, enable us to predict whether or not a precipitate forms when two solutions are combined. You will use these rules to explain the observations you make in today’s experiment.

When precipitation reactions occur we can write the complete balanced equation, or we can write the net ionic equation. A balanced equation includes all of the species in solution, and a net ionic equation includes only the species that are involved in the precipitation reaction. The following example shows how one would write a balanced equation and a net ionic equation for the reaction between silver nitrate and sodium chloride.

\[
\text{NaCl}(ag) + \text{AgNO}_3(aq) \rightarrow \text{AgNO}_3(s) + \text{NaCl} \quad \text{(balanced equation)}
\]

\[
\text{Ag}^+(aq) + \text{Cl}^-(aq) \rightarrow \text{AgCl}(s) \quad \text{(net ionic equation)}
\]

The ions that remain in solution when a precipitation reaction occurs are called spectator ions. Spectator ions are not included in net ionic equations.

Table 1. Solubility Rules for Ionic Compounds in Water

<table>
<thead>
<tr>
<th>Soluble Ionic Compounds</th>
<th>Insoluble Ionic Compounds</th>
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</thead>
<tbody>
<tr>
<td>Compounds of Group IA ions (Li⁺, Na⁺, K⁺, Rb⁺, Cs⁺) and ammonium (NH₄⁺).</td>
<td>Metal hydroxides are insoluble except those of Group 1A and larger members of Group 2A.</td>
</tr>
<tr>
<td>Common nitrates, acetates, perchlorates.</td>
<td>Common carbonates and phosphates are insoluble except Those of Group 1A and NH₄⁺.</td>
</tr>
<tr>
<td>Common chlorides, bromides, iodides except those of Ag⁺, Pb²⁺, Cu⁺ and Hg²⁺. Fluorides are soluble except those of Pb²⁺.</td>
<td>Common sulfides are insoluble except those of Group 1A, Group 2A and NH₄⁺.</td>
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<tr>
<td>Sulfates are soluble except those of Ca²⁺, Sr²⁺, Ba²⁺, Ag⁺ and Pb²⁺.</td>
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</tbody>
</table>
Procedure

Part I. The Combination and Observation of Known Chemicals

The chart at the end of this experiment will be filled out with observations made throughout the experiment. The first chemical compound to be tested is NaCl:

1. Appearance: color, texture, size of crystals (if applicable), etc.
2. Smell, if applicable (Caution: Do not directly smell chemicals. Fan some of the vapors toward your nose, also known as wafting).
3. Water soluble: Dissolve 0.1 g of the solid (about the size of a match head) in 0.5 mL of deionized water in a small test tube. A glass stirring rod can be used to help dissolve the solid.
4. pH: Is it acidic, basic, or neutral? Dip the glass stirring rod into the solution and touch it to a piece of litmus paper. If it turns the red litmus blue, the solution is basic. If it turns the blue litmus red, the solution is acidic. If no change occurs in either case, the solution is neutral.
5. Using a plastic, disposable pipette, add 2-3 drops of the NaCl solution (from step 3) to 2-3 drops of H₂SO₄, NaOH, HCl, AgNO₃, and BaCl₂. Did a precipitation appear? Did a reaction occur such as the production of a gas? Be sure to record any changes/reactions on the chart (Note: When reacting two liquids solutions together, add one or two drops of each).
6. If a solid substance does not dissolve, drop the reagents directly on a small quantity (about the size of a match head) of the solid substance and record your observations.
7. When the row for NaCl is complete, repeat this procedure with these solids (CaCl₂, NaHCO₃, CaCO₃, and C₁₂H₂₂O₁₁) and the following solutions (H₂SO₄, HCl, CH₃COOH, NH₄OH, and NaOH).

Part I B—Net Ionic Equations

Write the net ionic equations for each precipitation reaction in your data table.

Part II. Identification of Unknown Chemicals

Be sure to record the identity of your unknown solid compound and your unknown solution and the unknown number in the space provided at the bottom of the chart.

References


## Data Table—Experiment 5: Identification of Common Chemicals

<table>
<thead>
<tr>
<th></th>
<th>Appearance</th>
<th>Smell</th>
<th>Water Soluble</th>
<th>pH</th>
<th>H$_2$SO$_4$</th>
<th>NaOH</th>
<th>HCl</th>
<th>AgNO$_3$</th>
<th>BaCl$_2$</th>
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<tbody>
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<td>NaCl</td>
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<td>CaCl$_2$</td>
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<td>CaCO$_3$</td>
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<td>C$<em>{12}$H$</em>{22}$O$_{11}$</td>
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Unknown solid is: ______________________  Unknown liquid is: ________________________