Reading the River, 2001

Water Testing - A Unit for High School Chemistry
Licking River Watershed

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Water Testing for Contaminants in Streams
of the Licking River Watershed

Grade Level: High School Chemistry (11th and 12th)

Objectives
As a result of this lab activity, the student will:
1. Learn to use simple qualitative tests to identify cations and anion by testing the water samples for chemical impurities.
2. Become aware of water quality and the environmental issues concerning water that are vital to our world.
3. Learn to collect samples, prepare data tables, record results of experimentation and analyze data.
4. Learn different means of determining ion concentrations.
5. Use appropriate procedures in conducting a variety of chemical tests.
6. Implement different sources of technologies (e.g. water chemistry kits, CBL Units, computers, etc.) to analyze and research related topics.

PROGRAM OF STUDIES

Scientific Inquiry

- Identify and refine questions that can be answered through scientific investigations combined with scientific information
- Use appropriate equipment (e.g. water chemistry kits), tools (e.g. Lab equipment), techniques (e.g. lab and computer skills), technology (e.g. CBL Units and computers) in scientific investigations.
- Design and conduct different kinds of scientific investigations to answer different kinds of questions.
- Communicate (e.g. data tables, write) the results of scientific investigations.

Conceptual Understandings

- Distinguish between physical and chemical properties and changes.
- Plan, demonstrate, relate, and analyze the qualitative tests used in water testing.
- Be able to use scientific equipment properly.
- Using the scientific method in the analysis of data.
- Be able to use modern technologies to sort and arrange data.
Applications/Connections

- To make students aware of water quality and the environmental issues concerning water that are vital to our world.
- Recognize how science is used to understand problems in the environment.

CORE CONTENT

Structure and Properties of Matter

- SC-H-1.2.1 – Atoms interact with each other by transferring or sharing outermost electrons. These outer electrons govern the chemical properties of the element.
- SC-H-1.2.4 – The physical properties of compounds reflect nature of the interactions among molecules.
- SC-H-1.2.5 – The chemical properties of compounds reflect the nature of the interactions among ions.
- SC-H-1.1.1 – Matter has measurable properties.
Lesson Context

Chemical tests to identify properties and the presence of certain ions can be conducted in a lab setting. These tests will give students a better understanding of what can be in a sample of water taken from streams that supply the Licking River. An additional benefit will be to help make them aware of pollution in our waterways and its effect on our environment.

Explanations/Definitions of Concepts

Chemists can identify and detect ions in water samples in various ways. In this activity, students will use certain on-site tests such as oxygen content, temperature, conductivity, and pH; and then bring samples back to the lab to check for the presence of certain ions.

The tests the students will perform in the lab are confirming tests. That is, the test is positive if it confirms that the ion in question is present. In a confirming test, students will look for a change in color or the appearance of an insoluble material called a precipitate. Absence of color or precipitate (negative test) doesn’t necessarily mean the ion is not present. The ion could be present in very small amounts.

Students will test for the presence of the cations (positively charged ions) Fe$^{3+}$, iron III and Ca$^{2+}$, calcium. They will also test for the anions (negatively charged ions), Cl$^{-}$, chloride and SO$_4^{2-}$, sulfate. Students will perform each confirming test on three different samples:

- A reference solution (known to contain the ion of interest)
- Stream sample (which may or may not contain the ion)
- A control (distilled water, known not to contain the ion)
Activity: Stream Monitoring

Objectives:

As a result of this lab activity, the student will:

1. Learn to collect samples, prepare data tables, record results of experimentation and analyze data.
2. Use appropriate procedures in conducting a variety of chemical tests.
3. Implement different sources of technologies (e.g. water chemistry kits, CBL Units, computers, etc.) to analyze and research related topics.

Day 1:

On-Site Testing
(Divide students into groups of two and visit various sites in the area; be sure the collection is done at different streams.)

Materials Needed:
(per group)
1. La Motte Test Kit (all instructions included):
   ✓ Dissolved Oxygen Kit Model EDO-Code 7414
   ✓ Wide Range pH Model P-5085 – Code 2119
   ✓ Conductivity Tester TDSTester 3
   ✓ Thermometer Model 545 – Code 1066
2. CBL Units (for pH confirmations):
3. Sample jars previously rinsed with distilled water
4. Notebook for recording results of test
5. Waste water bottle

Advanced Preparation:
1. Discuss with the students the instructions needed for conducting each test.
2. Detailed map of streams in the area for selection of sample sites.
3. Discuss with students the contents of their data tables:
   river basin          flow rate          dissolved oxygen
   stream name          temperature         conductance
   sampling site         pH                date and time
Day 2:
1. Comparison of data collected at each site.
2. Students develop data table specific for their site.

Day 3:
Laboratory Activity: Water Testing (Ions)

Purpose: Students test different water samples for the presence of dissolved ions: iron III, calcium, chloride, and sulfate. The qualitative analysis procedures in this activity are based on a "confirming test" approach.

Time: One class period

Materials (for a class of 24 working in pairs)
- 12 wash bottles
- 36 test tubes
- 12 10-ml graduated cylinders
- 12 test tube racks
- 12 marking pencils
- 48 dropping bottles
- 4-5 burets for dispensing reference solutions
- 4 L distilled water

Test reagent solutions in dropper bottles [important ion]
- 50 ml 0.5 M KSCN (potassium thiocyanate, 2.4 g/50 ml) [SCN⁻ ions]
- 50 ml 0.1 M Na₂C₃O₄ (sodium oxalate, 0.67 g/50 ml) [C₂O₄²⁻ ion]
- 50 ml 0.1 M HC₂H₃O₂ (acetic acid, 0.3 ml conc. Acetic acid/50 ml)
- 50 ml 0.1 M AgNO₃ (silver nitrate, 0.85 g/50 ml) [Ag⁺ ions]
- 50 ml 0.1 M BaCl₂ (barium chloride, 1.2 g BaCl₂·2H₂O/50 ml) [Ba²⁺ ion]

Reference ion solutions:
- 200 ml 0.1 M Fe(NO₃)₃ (iron III nitrate, 8.0 g Fe(NO₃)₃·9H₂O/200 ml) [Fe³⁺ ion]
- 400 ml 0.1 M CaCl₂ (calcium chloride, 4.4 g/400 ml) [Ca²⁺ ion and Cl⁻ ion]
- 200 ml 0.1 M FeSO₄ (iron II sulfate, 5.6 g FeSO₄·7H₂O/200 ml) [SO₄²⁻]

Note: You may want to dispense the reference –ion solutions from burets located centrally.
Expected results:

<table>
<thead>
<tr>
<th>Reference solutions</th>
<th>Color</th>
<th>Precipitate or Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe^{3+}</td>
<td>Red</td>
<td>Fe(SCN)^{2-} iron thiocyanate complex</td>
</tr>
<tr>
<td>Ca^{2+}</td>
<td>White</td>
<td>CaC_{2}O_{4} calcium oxalate precipitate</td>
</tr>
<tr>
<td>Cl^{-}</td>
<td>White</td>
<td>AgCl silver chloride precipitate</td>
</tr>
<tr>
<td>SO_{4}^{2-}</td>
<td>White</td>
<td>BaSO_{4} barium sulfate precipitate</td>
</tr>
</tbody>
</table>
Laboratory Activity: Water Testing

Objectives:

1. Learn to use simple qualitative tests to identify cations and anion by testing the water samples for chemical impurities.
2. Learn to collect samples, prepare data tables, record results of experimentation and analyze data.
3. Learn different means of determining ion concentrations.
4. Become aware of water quality and the environmental issues concerning water that are vital to our world.

Data Table

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Color</th>
<th>Precipitate</th>
<th>Is Ion Present?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe^{3+} reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca^{2+} reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl- reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO_{4}^{2-} reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prepare a data table similar to the one shown above in your laboratory notebook. Here are some suggestions to guide your ion analysis:

1. If the ion is in the sample water, it will probably be present in a lower amount than in the same volume of reference solution. Thus the color or quantity of precipitate produced in the water sample will be less than in the reference solution.
2. When completing an ion test, mix the test tube contents thoroughly, unless the instructions give other directions.
3. In a confirming test based on color change, so few color-producing ions may be present that you remain doubtful the reaction actually occurred. Here are several ways to decide whether the expected color is actually present:
   - Look through the side of the tube. Placing a sheet of white paper behind or below the test tube may make any color more visible.
Compare the color of the control (distilled water) test to that of sample water. Distilled water doesn’t contain any of the ions tested. Thus even a faint color in the sample water confirms that the ion is present.

4. In a confirming test involving a precipitate, you may remain uncertain whether a precipitate is present even after thoroughly mixing the solutions. In this case shine a light beam through the tube to see whether the beam’s path can be clearly seen in the liquid. Such light scattering confirms the presence of a precipitate in the form of colloidal particles.

Procedure
1. Wash three test tubes thoroughly with tap water and rinse with distilled water.
2. Measure 2 ml of sample water in a graduated cylinder; pour the water into one test tube. Use a grease pencil to mark the 2-ml level on the outside of the tube. Mark the other two tubes with a line at the same level. Label the three test tubes Reference [R], Sample Water [SW], and Control [C].
3. Complete each of the following four tests on the respective reference solution provided by your teacher, on sample water, and on a control sample of distilled water.

Iron (III) Ion Test (Fe$^{3+}$)
1. Pour 2 ml of iron [III] reference solution into the clean Reference test tube.
3. Mix the test tube contents thoroughly. Record your observations. The confirming test you observed for Fe$^{3+}$ can be represented as follows:

\[
\text{Iron [III] ion} + \text{Thiocyanate ion} \rightarrow \text{Iron [III] thiocyanate ion (red color)}
\]

\[
\text{Fe}^{3+}(aq) + \text{SCN}^{-}(aq) \rightarrow \text{Fe(SCN)}^{2+}(aq)
\]
4. Repeat the iron [III] ion test on a 2-ml sample of water and on a 2-ml sample of distilled water, placing each sample in its properly labeled test tube. Record your observations and conclusions.
5. Discard the test tube contents as instructed by your teacher. Wash the tubes thoroughly with tap water and rinse with distilled water before continuing with the next test.

Calcium Ion Test (Ca$^{2+}$)
1. Pour 2 ml of calcium ion reference solution into the clean Reference test tube.
2. Add three drops of dilute acetic acid (HC$_2$H$_3$O$_2$).
3. Add three drops of sodium oxalate (Na$_2$C$_2$O$_4$) solution to the tube.
4. Mix the test tube contents thoroughly. Record your observations. The confirming test you observed for Ca$^{2+}$ can be represented as follows:

\[
\text{Calcium ion} + \text{Oxalate ion} \rightarrow \text{Calcium oxalate (precipitate)}
\]

\[
\text{Ca}^{2+}(aq) + \text{C}_2\text{O}_4^{2-}(aq) \rightarrow \text{CaC}_2\text{O}_4(s)
\]
5. Repeat the calcium ion test on a 2-ml sample of water and on a 2-ml sample of distilled water, placing each sample in its properly labeled test tube. Record your observations and conclusions.

6. Discard the test tube contents as instructed by your teacher. Wash the tubes thoroughly with tap water and rinse with distilled water before continuing with the next test.

**Chloride Ion Test (Cl⁻)**

1. Pour 2 ml of chloride ion reference solution into the clean Reference test tube.
2. Add three drops of silver nitrate (AgNO₃) test solution. Avoid contact with skin.
3. Mix the test tube contents thoroughly. Record your observations. The confirming test you observed for Cl⁻ can be represented as follows:

   \[
   \text{Silver ion} \quad \text{Chloride ion} \quad \text{Silver chloride}
   \]

   \[
   \text{(test solution)} \quad \text{(reference solution)} \quad \text{(precipitate)}
   \]

   \[
   Ag^+(aq) + Cl^-(aq) \rightarrow BaSO₄(s)
   \]

4. Repeat the chloride ion test on a 2-ml sample of water and on a 2-ml sample of distilled water, placing each sample in its properly labeled test tube. Record your observations and conclusions.
5. Discard the test tube contents as instructed by your teacher. Wash the tubes thoroughly with tap water and rinse with distilled water before continuing with the next test.

**Sulfate Ion Test (SO₄²⁻)**

1. Pour 2 ml of sulfate ion reference solution into the clean Reference test tube.
2. Add three drops of barium chloride (BaCl₂) test solution.
3. Mix the test tube contents thoroughly. Record your observations. The confirming test you observed for the SO₄²⁻ can be represented as follows:

   \[
   \text{Barium ion} \quad \text{Sulfate ion} \quad \text{Barium sulfate}
   \]

   \[
   \text{(test solution)} \quad \text{(reference solution)} \quad \text{(precipitate)}
   \]

   \[
   Ba^{2+}(aq) + SO₄^{2-}(aq) \rightarrow BaSO₄(s)
   \]

4. Repeat the sulfate ion test on a 2-ml sample of water and on a 2-ml sample of distilled water, placing each in its properly labeled test tube. Record your observations and conclusions.
5. Discard the test tube contents as instructed by your teacher. Wash the tubes thoroughly with tap water and rinse with distilled water.
6. Wash your hands thoroughly before leaving the laboratory.

**Questions**

1. (a) Why was a control used in each test?
   (b) Why was distilled water chosen as the control?
2. Describe some difficulties associated with the use of qualitative tests.
3. These tests cannot absolutely confirm the absence of an ion. Why?
4. How might your observations have changed if you hadn’t cleaned your test tubes thoroughly between each test?
Assessment

1. Monitor students during the stream visit to assess ability to properly use test kits.
2. Assess data tables to determine that all information is recorded properly. [Stream samples]
3. Monitor students during laboratory activities to determine the proper conducting of tests. [Ion testing]
4. Have students answer all post-lab questions.
SCORING GUIDE

Water Testing – The Licking River Watershed

<table>
<thead>
<tr>
<th>3 points</th>
<th>7 points</th>
<th>10 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student requires assistance in using</td>
<td>Student can use monitoring kits with</td>
<td>Student is very effective in using monitoring</td>
</tr>
<tr>
<td>monitoring kits.</td>
<td>little assistance.</td>
<td>kits.</td>
</tr>
<tr>
<td>Student needs assistance in taking</td>
<td>Student can properly conduct the majority of</td>
<td>Student can measure accurately.</td>
</tr>
<tr>
<td>proper measurement.</td>
<td>measurements.</td>
<td></td>
</tr>
<tr>
<td>Student has trouble designing data table.</td>
<td>Student needs little help with data tables.</td>
<td>Student can compile data tables and record</td>
</tr>
<tr>
<td></td>
<td></td>
<td>information.</td>
</tr>
<tr>
<td>Student cannot properly identify ions.</td>
<td>Student can determine the ions with little</td>
<td>Student can identify all ions.</td>
</tr>
<tr>
<td></td>
<td>assistance.</td>
<td></td>
</tr>
<tr>
<td>Student cannot properly answer all questions.</td>
<td>Student can answer most of the questions.</td>
<td>Student is able to response correctly to all</td>
</tr>
<tr>
<td></td>
<td></td>
<td>questions.</td>
</tr>
</tbody>
</table>

Score __________ /50 points
RESOURCES

www.siue.edu/OSME/river/SAMP_chem.html

Lapeer.org/ChemCom/Unit1/1B.8WaterTestingLab.html