Water Magic

Several good friends have just returned from a magic show. Among the strange and wondrous tricks that the magician and her assistants performed, one fairly simple trick especially captured the group's attention. In this trick, the magician placed several curiously shaped glass containers on a table. The containers held a clear liquid. As the magician waved her magic wand over the bottles, the liquid in each bottle changed to a different color.

On the ride home, the friends speculated about how this trick was done. One person suggested that the magician dropped powdered food coloring into the containers. Another person thought that special lighting was used so that the liquids only appeared to change color. Another person offered that special prisms were set up to mask the actual colors all along, and the prisms were turned at the exact moment that the magician waved her wand.

The friends agreed that a magician added something to the liquid, but she didn't have time to add something different to each container. Since all the liquids started out the same color and ended up a different color, is it possible that adding the same substance could turn each clear liquid a different color? One of the friends mentioned seeing a science teacher change the colors of an acid and a base solution by adding a few drops of liquid called an indicator to each solution. Could this be how the trick was done?

Investigation

It is up to you to determine what the possible liquid was and how the liquid made different colors appear. In this experiment, you will use the Vernier Go! Link and a pH Sensor to measure the pH of several samples of acid and base solutions. You will prepare a universal indicator solution and add it to each liquid sample. Finally, you will use a ProScope Digital Microscope to document the colors of each solution and use iPhoto software to prepare a report of your experiment.

Objectives

In this experiment, you will:

- Use a Vernier pH Sensor and Logger Lite software to measure and record the pH of several samples of acid and base solutions
- Use a ProScope Digital Microscope to document the colors of your liquid samples after an indicator solution has been added
- Identify a liquid as acidic or basic according to its pH
- Identify an unknown liquid as acidic or basic
- Report your test results using iPhoto software

Materials

- Macintosh computer with Mac OS X
- iPhoto software
- Bodelin ProScope Digital Microscope
- Bodelin USB Shot software
- Bodelin M50 lens
- Vernier Go! Link interface
- Vernier pH Sensor
- Logger Lite Software
- Clear plastic cups or small glass beakers
- Large cup or container of rinse water for the pH Sensor
- 100 mL graduated cylinder or another glass measuring vessel
- Water
- Vinegar
- Baking soda
- Rubbing alcohol
- Red cabbage, chopped
- Red cabbage indicator solution
- Teaspoon
- Tablespoon
- Aluminum foil or plastic food wrap
- Eyedropper or plastic Beral pipet

Pre-lab activity

Conduct research to define acids, bases, and indicators. In your science journal, briefly describe acids and bases. Tell the pH range for acids and bases. Describe how an indicator works when it is added to an acid or a base. Prepare a hypothesis that predicts the colors that you may see when you add a universal indicator to an acid, a base, or a neutral liquid.

Pre-lab preparation of the red cabbage indicator solution

Prepare the red cabbage indicator solution the day before your experiment, following the steps below:

1. Use a 100 mL graduated cylinder to measure out 80 mL of warm water. Add 20 mL of rubbing alcohol to the graduated cylinder, so that you have 100 mL of liquid.
2. Pour the water/rubbing alcohol mixture into a plastic cup or small beaker.
3. Add two tablespoons of chopped red cabbage to the container of liquid.
4. Cover the container with a piece of aluminum foil or plastic food wrap. Store the container in a safe place, as directed by your teacher. The red cabbage indicator solution is ready to use when the liquid is a deep red.

Procedure

Note: Split the work to save time. One or two students can prepare the liquids for testing and take digital images with the ProScope (Steps 1-4). Another one or two people should set up the pH Sensor and computer (Steps 5-14). Work together starting with Step 15.

1. Label five clear plastic cups 1-5. Use an eyedropper or plastic Beral pipet to obtain a small amount of your red cabbage indicator solution.
2. Use a graduated cylinder to measure out 25 mL of water. Pour the water into Cup #1. Place 2-3 drops of red cabbage indicator in Cup #1 and gently swirl the cup to mix.
3. Use a ProScope Digital USB Microscope to record the image of the liquid in Cup #1.
   a. Connect the ProScope to a USB port on the computer.
   b. Open the USB Shot application.
      You should now see an image on your computer screen.
   c. Focus the ProScope over the liquid using the M50 lens, then snap an image.
4. The images you take with the ProScope are located in the SNAP folder, which is in your Applications folder. Rename the images with the name of the liquid and drag them into a new folder you have created for this experiment.
5. Use the graduated cylinder to measure out another 25 mL of water and pour it into Cup #2. Add a level teaspoon of baking soda to Cup #2 and stir the mixture until all of the baking soda has dissolved. Place 2-3 drops of red cabbage indicator in Cup #2 and gently swirl the cup to mix.
6. Use the ProScope to record the image of the liquid in Cup #2.
7. Use the graduated cylinder to measure out 25 mL of vinegar. Pour the vinegar into Cup #3. Place 2-3 drops of red cabbage indicator in Cup #3 and gently swirl the cup to mix.
8. Use the ProScope to record the image of the liquid in Cup #3.
9. Obtain a large cup or container with tap water to use as a rinse between pH tests.
10. Connect the Go! Link interface to the computer and connect the pH Sensor to the Go! Link interface.
11. Open the Logger Lite software by double-clicking the Logger Lite icon on the desktop of your computer.
12. Choose Data Collection from the Experiment menu.
13. Choose Events with Entry from the Mode menu. In the Name dialog, type “Sample.” In the Short Name dialog, also type “Sample.” Click Done.

14 Carefully remove the small plastic storage bottle and lid from the pH Sensor. Put the storage bottle in a safe place where it won't be tipped over. It contains a special buffer solution that preserves the pH Sensor when it is not in use. Rinse the tip of the pH Sensor with lots of tap water.

15 Immerse the tip of the pH Sensor in Cup #1. Click Collect in the Logger Lite software. Watch the pH readings on the computer screen.

16 When the pH readings stabilize, click Keep. In the dialog that appears, type "1," then click OK. Record the pH and a description of the color of the liquid in your data table.

17 Remove the pH Sensor from Cup #1 and rinse the pH Sensor in the large cup of rinse water.

18 Immerse the tip of the pH Sensor in Cup #2. When the pH readings stabilize (be patient!), click Keep and type "2" in the dialog. Click OK. Record the pH and a description of the color of the liquid in your data table.

19 Remove the pH Sensor from Cup #2 and rinse the pH Sensor in the large cup of rinse water. Immerse the pH Sensor in Cup #3. When the pH readings stabilize, click Keep and type "3" in the dialog. Click OK. Record the pH and a description of the color of the liquid in your data table. Carefully pour the contents of Cups #2 and #3 into Cup #4. Swirl the cup gently to mix. Use the ProScope to record the images of the liquid in the cup.

20 Immerse the pH Sensor in Cup #4. When the pH readings stabilize, click Keep and type "4" in the dialog. Click OK. Record the pH and a description of the color of the liquid in your data table.

21 Ask your teacher for a sample of unknown liquid. Pour the unknown liquid into Cup #5 and add 2-3 drops of red cabbage indicator to Cup #5. Swirl the cup gently to mix.

22 Use the ProScope to record an image of the liquid in Cup #5. Immerse the pH Sensor in Cup #5. When the pH readings stabilize, click Keep and type "5" in the dialog. Click OK. Record the pH and a description of the color of the liquid in your data table.

23 Click Stop to halt the data collection.

24 Clean up your work area and dispose of the liquids as directed by your teacher. Rinse off the pH Sensor with lots of tap water and put the storage bottle back in place on the Sensor.

Data table

Cup #	Contents	pH	Description of Color of Liquid
1			
2			
3			
4			
5			

Analyzing your data

1. Based on the research that you conducted for the pre-lab activity, identify the liquids in the five cups as acids, bases, or neutral liquids.
2. Describe the color of the red cabbage indicator when it is added to an acid, a base, or a neutral liquid.
3. According to the results of your experiment, if you add red cabbage indicator to a liquid and the color changes to orange, what would be the pH of the liquid?
4. Identify your unknown solution as acidic or basic. Is your unknown a stronger acid or base than any of the liquids in Cups #1-4?
5. Use the results of your experiment to propose a method of setting up a magic trick similar to the one described in the opening scenario.
6. Prepare a report of your results, using iPhoto software to incorporate your digital images and data tables into your report.

Teacher Information

The measurement of pH uses a logarithmic, unitless scale. For common substances, a scale of 0–14 is used. Acidic substances have pH values below 7 and basic substances have pH values above 7. Neutral substances have a pH of exactly 7. The students may have heard or read that distilled water has a pH of 7, which is usually not the case. Distilled water normally has a pH that is slightly acidic because of the dissolved carbon dioxide that occurs in the distilling process. Absolutely pure water has a pH of 7.

Red cabbage contains a pigment called flavin. This pigment is also found in red poppies, blue cornflowers, grapes, and apple skin. The pH of the fruit or plant causes the pigment to show a specific color.

Students can use their data table file in their iPhoto presentation. You may want to explain the steps involved in exporting their files to iPhoto. To export a data table from a word-processing document or spreadsheet into iPhoto, follow these steps:

1. Take a screen shot of the information you want to include. Hold down the Command-Shift-4 keys and drag to highlight the area you want to select.

   A numbered file named Picture is created, such as "Picture 1."

2. Open the Preview application from the Dock or in the Applications folder. (Preview is included on every new Macintosh computer.)

3. Choose Open from the File menu, then locate and open your Picture screen shot file.

4. Choose Export from the File menu, name the file, and save it as a JPG file.

5. Open iPhoto and drag the JPG file into your Photo Library.

Materials

In this activity, the students will be measuring the pH of five cups of liquids. One of the cups will be an unknown liquid that you will prepare. An easy way to make an unknown liquid is to mix portions of vinegar and baking soda the day before the activity.

If you do not have measuring teaspoons and tablespoons, use two different sizes of plastic or metal spoons. The students will get good results whether or not they measure the vinegar and baking soda precisely.

For best results, the students should make up the red cabbage indicator solution a day ahead of time. If you do not have rubbing alcohol, soaking the red cabbage in water will work satisfactorily. Provide the students with very warm, but not hot, water and finely chop the red cabbage.

You may want to have the students make indicator paper with the leftover red cabbage indicator. Simply cut strips of any type of white paper and soak the strips in the red cabbage juice. Lay the strips on paper towels to air dry. The students can place drops of various liquids on the dry strips; the strips will change color according to the pH of the drops of liquid.

Sample data table

Cup #	Contents	pH	Description of Color of Liquid
1	Tap water	7.6	Greenish-yellow
2	Tap water and baking soda	9.3	Blue
3	Vinegar	2.8	Orange-red
4	Tap water, baking soda, and vinegar	6.4	Blue-green
5	Unknown	5.5	Purple

Answers to analyzing your data questions

1 Answers will vary. Depending on the nature of your local tap water, Cup #1 could be acidic, basic, or neutral. Cup #2 will be basic and Cup #3 will be acidic. Cup #4 should be slightly acidic, but it will depend on how much baking soda the team used in Cup #2. Cup #5 depends on the unknown that the team tested.

2 Answers will vary. The shades of blue, green, and yellow indicate basic liquids, the shades of red and purple indicate acidic liquids, and greenish-blue is near neutral.

3 Answers will vary, depending on the pH of the liquids that each team tested. In general, the students should predict the pH of an orange indicator color to be acidic, in the 2-4 pH range.

4 Answers will vary, depending on the unknown that each team tested.

5 Answers will vary. A typical response will suggest that liquids of several different pH values be placed on a table and a universal indicator, such as the red cabbage extract, is added to each liquid to achieve different colors.

6 Presentations will vary, but should include the ProScope images and the data from the five trials.

Extensions

1. Students can test the pH of other clear household liquids, such as Sprite or 7-Up, club soda, bottled water, or nail polish remover. They can prepare their own solutions by adding sugar, salt, or baking powder to water.
2. Students can conduct a chemical reaction that changes pH over time. An easy way to do this is to add one or two antacid tablets (such as Rolaids, Tums, or Alka-Seltzer) to a portion of vinegar. They should note the change in pH and the change in color of the indicator during the reaction.
3. Many common edible berries and the cooking spice turmeric can be used to make indicator solutions. You can help students prepare and test other indicators.

National Science Standards

This experiment provides direct alignment to national standards by allowing students to observe and measure pH, properties of acids and bases, properties of indicator solutions and interactions of substances. The design of the experiment also emphasizes alignment with measurement, inquiry, and investigative standards by having students use technology to practice and gain insight into these skills.

Content Standard A:

Science as Inquiry: B. 5-8

As a result of their activities in grades 5-8, all students should develop an understanding of

1 Abilities necessary to do scientific inquiry.

2 Understandings about scientific inquiry.

Content Standard B:

Physical Science: B. 5-8

As a result of their activities in grades 5-8, all students should develop an understanding of

2 Properties and changes of properties in matter.

Special thanks

This lesson was written by Linda Eller, Instructional Technology Coordinator of Teaching and Learning Academy, Memphis, TN, and edited by Vernier Software & Technology.