

Household Acids and Bases

TI-NSPIRE™ CX II / GO DIRECT® SENSORS

TEACHER NOTES

Science Objectives

- Use litmus paper and a pH Sensor to determine the pH values of household substances.
- Add cabbage juice to the same substances and determine different red cabbage juice indicator colors over the entire pH range.

Math Objectives

- Understand the logarithmic (base 10) of the pH scale.

Materials Needed

- TI-Nspire™ CX II
- Vernier® GDX pH Probe
- Vernier GDX to TI-Nspire Cable

Vocabulary

- Acid
- Base
- Indicator
- Litmus Paper
- pH

About the Lesson

- This activity makes use of the Vernier GDX pH Probe to measure the pH of various Household Chemicals.
- As a result, students will:
 - Determine which are acids and which are bases using litmus paper.
 - Determine which are acids and which are bases using red cabbage juice.
 - Determine which are acids and which are bases using the pH Probe.
 - Assess which method is most precise.

TI-Nspire™ Navigator™ System (if available)

Class Capture to monitor student progress.

Tech Tip:

Access free tutorials at

<http://education.ti.com/calculator/spd/US/Online-Learning/Tutorials>

Lesson Files:

Student Activity

- Household_Acids_Bases_Student.pdf
- Household_Acids_Bases_Student.doc

Activity Overview

1. Please print the student worksheet and make available to students before beginning the lab. Lab background information as well as lab procedures are included only in the student worksheet. Always remember to review any safety precautions thoroughly with your students prior to starting the lab.
2. Vernier Go Direct® (GDX) probes and sensors can be either directly connected to the TI-Nspire CX II with a Calculator Connection Cable (Mini-A to Micro-B USB) or through TI's Bluetooth Adapter. For this activity, we used the USB direct connection method. *Note: A TI-Nspire CX II is required to use the Go Direct probes, but this activity can also be done with other pH sensor, which can be used with either the TI-Nspire CX or TI-Nspire CX II.*
3. *Optional procedure* for the Bluetooth Adapter (instead of the USB cable), follow these pairing directions:
 - Turn the TI-Nspire™ CX II on.
 - Turn on the GDX Probe or Sensor of choice.
 - Plug the Mini-A end of the cable into the Npsire CX II and the Micro-B into the Bluetooth Adapter.
 - Press **[Menu]** on the TI-Nspire unit and choose **Add Vernier DataQuest**.
 - Select **Add Bluetooth Sensor** on the Handheld screen.
 - On the next screen, > **Connect for the Probe or Sensor** that you wish to add.
 - Choose OK on that screen and OK on the following screen.
 - The Probe or Sensor is now ready for use wirelessly.
 - *For more information on Go Direct Sensors, and TI Technology visit*
<https://education.ti.com/en/product-resources/go-direct>

Note: TI-Nspire CX II's Vernier DataQuest app can also support many of the newer Vernier GoDirect sensors, while also continues to support some of Vernier's older sensors and probes.

4. We estimate this experiment can be completed in on 45-60 minute class period.
5. Red cabbage juice solution can be prepared by boiling red cabbage in water. Alternatively, you can grind up red cabbage in a blender, and then strain it with a sieve to obtain the juice.
6. The use of 13 × 100 mm test tubes is suggested.
7. Suggested solution concentrations:
 - 0.1 M ammonia (6.7 mL concentrated NH₃ per 1 L) **HAZARD ALERT:** Both liquid and vapor are extremely irritating—especially to eyes. Dispense in a hood and be sure an eyewash station is accessible. Toxic by ingestion and inhalation. Serious respiratory hazard. **Hazard Code: A—Extremely hazardous.**
 - 0.1 M NaOH (0.40 g of NaOH per 100 mL to use as a drain cleaner solution) **HAZARD ALERT:** Corrosive solid; skin burns are possible; much heat evolves when added to water; very dangerous to eyes; wear face and eye protection when using this substance. Wear gloves.



Hazard Code: B—Hazardous.

1% detergent (1 g of solid detergent per 100 mL)

1% baking soda (1 g of NaHCO_3 per 100 mL)

Note: For safety reasons, 0.1 M NaOH solution is substituted for a drain cleaner (Drano) solution.

The hazard information reference is: Flinn Scientific, Inc., *Chemical & Biological Catalog Reference Manual*, (800) 452-1261, www.flinnsci.com. See *Appendix D* of this book, *Chemistry with Vernier*, for more information.

8. The soda pop should be colorless.
9. To speed the lab up, divide students into three groups. Have one group start with Litmus Paper, the next group with Red Cabbage Juice, and the third group with the pH Probe. Students can then rotate through the entire lab.
10. To reduce the amount of litmus used, cut strips into 1 cm pieces.
11. Be sure to demonstrate the pH Sensor cleaning sequence as a part of your pre-lab for this experiment.
12. Solutions can be made available to the students in 50 or 100 mL beakers. The 3 mL portions in Step 3 can be poured directly from the beakers, and pH tests can be made directly in the beakers.
13. Instead of Time or Events with Entry, the data will be gathered using the Live Reading displayed on the screen.
14. The electrode solution used in this experiment is pH 7 buffer solution. It can be purchased from chemical supply companies. Vernier Education sells a package of capsules for preparing buffer solutions of pH 4, 7, and 10 (Order Code PHB). The electrode solution can also be prepared using a recipe found in the *Handbook of Chemistry and Physics*. One such recipe specifies ingredients mixed in the ratio of 50 mL of 0.1 M KH_2PO_4 to 29.1 mL of 0.1 M NaOH. The 0.1 M KH_2PO_4 requires 13.7 g per 1 L of solution. The 0.1 M NaOH requires 4.0 g per 1 L of solution.
15. After your students finish using the pH Sensors, you should return the probes to the small plastic, buffer-filled bottles supplied by Vernier Education.
16. The stored pH calibration works well for this experiment.

SAMPLE RESULTS

Test Tube	Solution	Blue Litmus	Red Litmus	Red Cabbage Juice	pH
1	vinegar	pink	pink	red-pink	2.5
2	ammonia	blue	blue	blue-green	8.3
3	lemon juice	pink	pink	pink	2.7
4	soft drink	pink	pink	blue-pink	3.5
5	drain cleaner	blue	blue	yellow-green	12.0
6	detergent	blue	blue	blue-green	9.4
7	baking soda	blue	blue	blue	8.2

Questions

- Which of the household solutions tested are acids? How can you tell?

Answer: Solutions that turn red with litmus or cabbage juice or have a pH less than 7 are acids.

- Which of the solutions are bases? How can you tell?

Answer: Solutions that turn blue with litmus or cabbage juice or have a pH more than 7 are bases.

- What color(s) is red cabbage juice indicator in acids? In bases?

Answer: Red in acids and blue in bases.

- Can red cabbage juice indicator be used to determine the strength of acids and bases? Explain.

Answer: Red cabbage juice can give a relative strength of an acid or base by observing the shades of color in the solutions.

- List advantages and disadvantages of litmus and red cabbage juice indicators.

Answer: Litmus is the least effective indicating only whether it is an acid or a base, but is readily available and gives a quick test.

Red cabbage juice gives an indication of the strength of the acid or base, but is more difficult to obtain and store.

The pH Probe gives the most accurate measurement of the acidity or basicity of the solutions, but requires more set up time than litmus paper.

This activity was adapted from Experiment #21: Household Acids & Bases from the *Science with TI-Nspire Technology™*, ©2019 Vernier®.