EXPLORATIONS

Activity 5

Electrolytes: Which Liquid Produces the Most Volts?

Objectives

- To understand that acids and bases are electrolytes. This is a physical property of matter
- To be able to measure the voltage produced by an electrolyte using the voltage sensor

Materials

- TI-73
- Unit-to-unit cable
- CBL 2™
- Voltage sensor
- Electrolytes (liquid samples)
- Liquid containers (medicine cups or 50 ml beakers)
- Electrodes (2" copper strip, 2" magnesium strip)
- Distilled water for rinse water
- Beaker or container for rinse water
- Two wires with alligator clips attached (optional)
- Data Collection and Analysis pages (p. 44 – 46)

In this activity you will

- Test some liquids that you might find at home to determine if they are acids, neutrals, or bases.
- Use the CBL 2™ with the voltage sensor to find the voltage of various liquids.
- Compare the voltages of acids to the voltages of bases.

Problem

Does an acid or a base produce the highest voltage?

Introduction

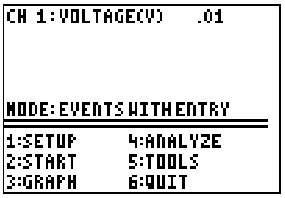
Acids and bases are electrolytes. They can, therefore, conduct electricity because of the ions they produce in solutions. These ions are either hydrogen (H^+) in acids or hydroxide (OH^-) in bases.

Hypothesis

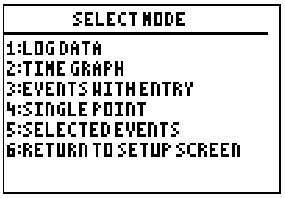
Before testing voltage, test liquids for pH values to predict which acid and base will produce the highest voltage. Record your prediction on the **Data Collection and Analysis** page.

Procedure: Collecting the Data

1. Collect the electrolytes (liquid samples) and place them in containers as directed by your teacher.
2. Put the electrodes into the first electrolyte.
3. Plug the voltage sensor into Channel 1 (**CH 1**) on the CBL 2™.
4. Start the DATAMATE program.
5. The Main Screen is displayed. **CH 1:VOLTAGE(V)** is displayed.



6. Select **1:SETUP**. Next, select **MODE**; then select **3:EVENTS WITH ENTRY**.



7. Select **1:OK** to return to the Main Screen.
8. Attach the red and black leads to the electrodes. If you are using wires and alligator clips, connect them between the voltage sensor leads and the electrodes.
9. When you are ready to begin, select **2:START**. The screen displays **PRESS ENTER TO COLLECT OR STO TO STOP**.
10. When the voltage reading is steady, press ENTER.
11. The program asks you to enter a value. This value is the number of your liquid sample, NOT the voltage reading. Type the number for this sample (for example, if this is your first sample, type **1**) and press ENTER. Record the liquid name beside the number in the table on the **Data Collection and Analysis** page. The program returns to the data collection screen, ready for your next liquid sample.
12. Rinse the electrodes and put them into the next liquid.
13. Repeat steps 8 through 12 for each sample, using the number for the sample when the program asks for a value after you have the voltage. After you enter the first sample number, the last number you used is displayed at the bottom of the screen.
14. After you have collected the voltage reading for the last sample, press STO▸. A scatter plot is displayed showing the voltage reading for all of the samples. Use ▸ and ◂ to move to each data point and record the values in the table on the **Data Collection and Analysis** page.
15. To exit from the DATAMATE program, press ENTER to return to the Main Screen. Select **6:QUIT** and press ENTER.

Data Analysis

Use the data you collected to answer the questions on the **Data Collection and Analysis** page.

Extension

Repeat this activity using different combinations of electrodes instead of different liquids.

1. Obtain different combinations of electrodes from your teacher.
2. Choose the best electrolyte from this activity.
3. Experiment with different combinations of electrodes and measure the voltage for each combination.
4. Record the electrode combinations and their voltages in the table on the **Data Collection and Analysis** page.

Data Collection and Analysis

Name _____

Date _____

Activity 5: Electrolytes: Which Liquid Produces the Most Volts?

Problem

Does an acid or a base produce the highest voltage?

Hypothesis

Based on the pH values you obtained for the liquids, predict which acid and base you think will produce the highest voltage.

1. The acid that will produce the highest voltage is:

   _____

2. The base that will produce the highest voltage is:

   _____

3. The liquid that will produce the highest voltage is:

   _____

Data Collection

Record your pH values in the table below. After testing, use the displayed scatter plot and fill in the voltage readings.

Sample Number	Liquid	pH Value	Voltage (V)
1			
2			
3			
4			
5			
6			
7			

Data Analysis

1. Compare your predictions for the best electrolyte to the data collected during the lab. If you were correct, what made you think they would be the best? If your prediction was incorrect, why did you think the others would be the best electrolytes?

   _____

   _____

2. What did the best electrolytes have in common? What did the worst electrolytes have in common?

   _____

   _____

3. Based on the data collected during this lab, what conclusion can you make about acids and bases as electrolytes?

   _____

   _____

   What characteristic of acids and bases is most responsible for this?

   _____

   _____

Conclusion

1. The liquid that produced the highest voltage is _____ .
2. It is an acid / a base. (Circle the correct response.)

Application

1. Make a data table below and record the electrode combinations and their voltages.

Electrode Combination	Voltage (V)

2. List the combinations of electrodes that produced the highest voltage and the lowest voltage below.

Highest Voltage (V)	Lowest Voltage (V)

3. What do the electrodes that had the highest readings have in common?

_____

_____

_____

4. Using the Periodic Table of the Elements, find the elements for the various electrodes and examine the locations of the elements. Do you see any patterns among those with the highest voltage and those with the lowest? Explain.

_____

_____

_____

Teacher Notes

Activity 5

Electrolytes: Which Liquid Produces the Most Volts?

Objectives

- To understand that acids and bases are electrolytes. This is a physical property of matter
- To be able to measure the voltage produced by an electrolyte using the voltage sensor

NSES Standards

- Physical Science: Properties and changes of properties in matter
- Physical Science: Transfer of energy

Preparation

- Use small plastic bathroom cups housed in egg cartons for the household liquid samples.
- Suggested liquids: lemon-lime soda, diluted lemon juice (4 parts water to 1 part lemon juice), diluted vinegar (4:1 works for this, too), diluted ammonia (4:1), diluted dishwashing soap (25 ml/liter of water), a baking soda solution (25 grams/liter of water), and distilled or tap water (use whichever is closest to a pH of 7). This combination gives you three acids, three bases, and a neutral solution for the students to measure.
- The liquids you choose may be used straight from the bottle, such as lemon-lime soda, or you may have to dilute them, as in the case of vinegar and ammonia.
- It is recommended that you choose clear, or nearly clear, liquids to keep the students from being able to readily tell the difference between them.
- Provide distilled water for rinsing pH probes between trials. Crook-necked bottles work well.
- By testing for pH, the students learned which household liquids were the strongest acids and bases. The students will now determine which are the best electrolytes (that is, which produce the highest voltage).
- Remind the students that they need to keep the electrodes the same distance apart for each trial. The distance will depend on the type of container you have chosen to use. You may either give them a distance or just let them choose a distance they want to use, reminding them to keep it constant. Failure to do so will affect their results. The students will need to rinse the electrodes after taking them out of each solution and at the end of the lab.
- The voltage sensor leads should be connected to wires (one black and one red) that have alligator clips on one end and about 2 cm of bare wire on the other. The students can then leave the voltage sensor's smaller clips attached to the bare wire and connect the sturdier alligator clips to the electrodes.

Management

- Ideally, the students will figure out that if they get a negative voltage, they should reverse the wires the electrodes are attached to. It may be necessary to tell them this in advance, or you may prefer to explain this as you begin to get questions about it when they start the lab.
- Assign these student jobs for this lab:
  - Materials/setup person (sets up samples, probe)
  - Tech person (operates CBL 2™)
  - Data recorder (reads pH/voltage readings from the TI-73 at each collection interval)
  - Runner (brings CBL 2 to the computer to print out graphs with TI-GRAPH LINK™ and brings **Data Collection and Analysis** pages to the teacher)
- Clear covered plastic shoeboxes will hold a CBL 2, pH probe, cups, rinsing bottle, and other equipment neatly at each station. If students are sharing one pH probe, representatives from each lab group would bring test beverages in the cups to the probe. Mounting the probe on a ring stand is an option.
- Students can record pH/voltage readings in their lab journals as they are displayed on the TI-73. This keeps them engaged throughout the data collection period and if they lose their data/graph later, they can still write up their lab report. Students can also access the data in the TI-73 lists after data collection. You can send the lists to all students' calculators using APPS **1:Link**:

  a. Press APPS.

  b. Press ENTER to select **1:Link**.

  c. Select **4:List** and press ENTER.

  d. Press ▼ to move the ▶ beside the list you wish to send. Press ENTER.

  e. Repeat step **d** for each list you wish to send.

  f. Set the receiving unit by pressing APPS ENTER ▶ to select **RECEIVE**. Press ENTER. **Waiting…** displays on the TI-73 screen.

  g. On the sending unit, press ▶ to select **TRANSMIT** and press ENTER.

  For more permanent storage of data, use TI-GRAPH LINK™ to save the lists in a computer folder.
- Students can assess each other using a teamwork rubric after the lab. Provide a checklist of positive and negative behaviors. Copy these on quarter sheets of paper.