Chemistry

CONCEPTS AND APPLICATIONS

CALCULATOR-BASED LABS

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Concepts and Applications

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936 Eastwind Drive
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ISBN 0-02-820361-9
Printed in the United States of America.

1 2 3 4 5 6 7 8 9 024 05 04 03 02 01 00 99

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To the Teacher

This Calculator-based Laboratory, CBL, booklet is designed for use with selected ChemLabs from Glencoe's ***Chemistry: Concepts and Applications Student Edition.*** Page references to the ChemLabs in the student text are given at the beginning of each experiment. This lab manual describes and explains the use of the Calculator-based Laboratory and probes as an alternative means of carrying out ten Chemlabs directly correlated with chapters in the textbook. Sample data and answers to questions can be found in the ***Teacher Wraparound Edition.***

The CBL System is an interface that collects data from the probes and sends the information to the calculator. The calculator, in turn, runs stored data collection and processing programs, which interpret and plot data obtained from the CBL System.

Macintosh or PC computers may be substituted for the calculator. A computer interface (microcomputer) is then substituted for the CBL System. The computer can run a variety of data analysis programs, which will graph and analyze data collected from the interface.

Vernier Software and Pasco Scientific carry probes, software, and computer interfaces. The CBL System is by Texas Instruments and is compatible with Texas Instrument calculators, which include the TI-73, TI-82, TI-83, TI-85, TI-86, TI-89, and TI-92. When using a TI-92, a slight difference in entering probe information may occur with data collection programs.

The TI-Graph Link provides a link between your TI Graphing Calculator and a Macintosh or PC-compatible computer. It is essential to have one in order to transfer programs and data between your computer and calculator. The Graph Link also allows you to copy and paste the calculator display into your computer. The CHEMBIO data collection program is available to order from Vernier Software or may be downloaded from its web site. Select the version to match your TI Graphing Calculator model. Follow the instructions that come with the Graph Link to download programs onto your calculator. Once loaded, the programs can be transferred to other calculators through the calculator link cable.

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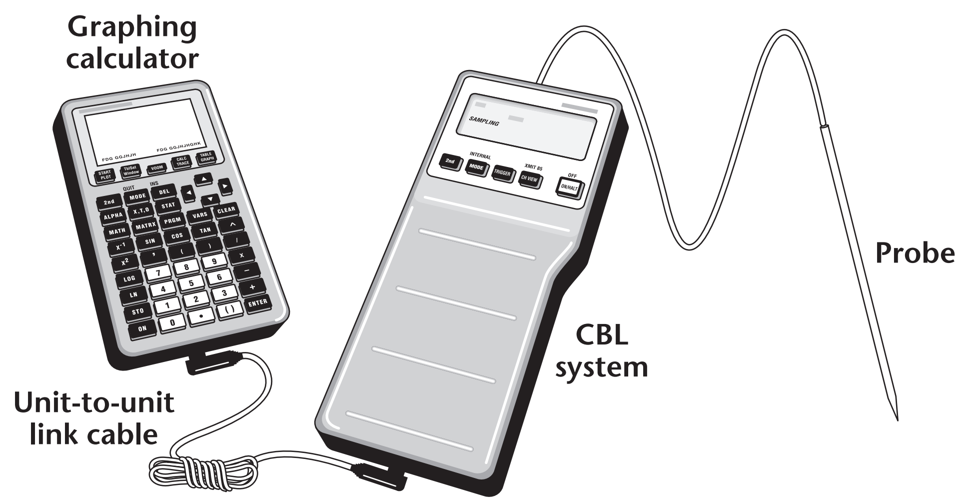
General Calculator-based Setup:



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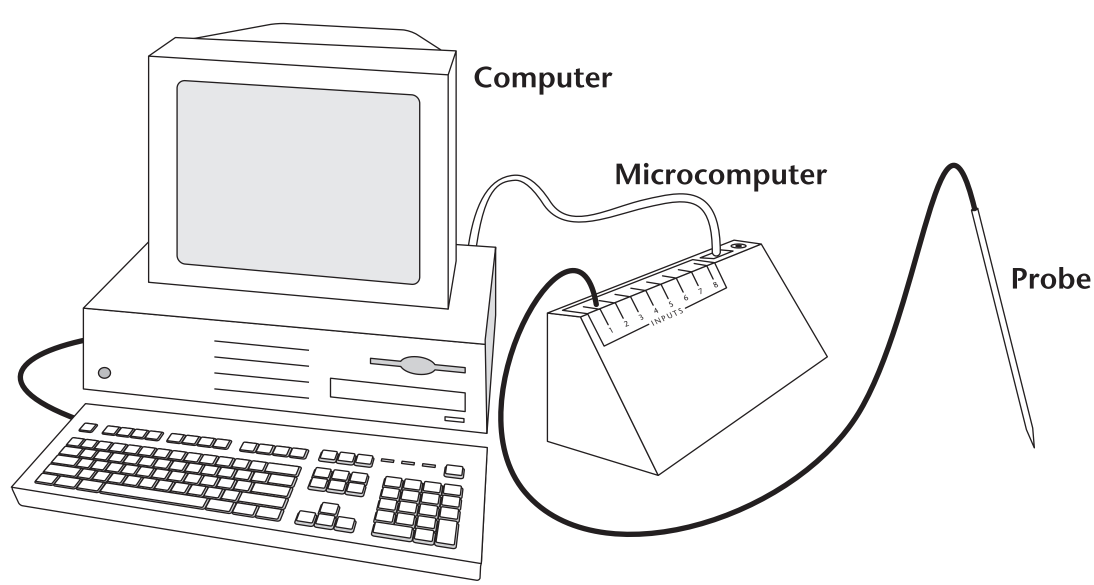


Name

Date Class

The Periodic Table of the Elements

Experiment 1
Use with ChemLab 3 pages 100–101

Problem
What is the pattern of metallic and nonmetallic properties of the elements in the periodic table?

Objectives
- **Observe** the properties of samples of elements, including metals, nonmetals, and metalloids.
- **Classify** the elements as metals, nonmetals, or metalloids.
- **Analyze** your results to discover trends in the properties of the elements in the periodic table.

PREPARATION

Materials
Stoppered test tubes containing small samples of:
carbon, nitrogen, oxygen, magnesium, aluminum, silicon, red phosphorous, sulfur, chlorine, calcium, selenium, tin, iodine, and lead
Plastic dishes containing samples of:
carbon, magnesium, aluminum, silicon, sulfur, tin
1*M* HCl
test tubes (6)
test-tube rack
10-mL graduated cylinder
spatula
small hammer
glass marking pencil
CBL System
TI Graphing Calculator with unit-to-unit link cable
CBL AC adapter (optional)
voltage probe
9-Volt battery
9-Volt battery clip
alligator clips (2)
paper clips (2)

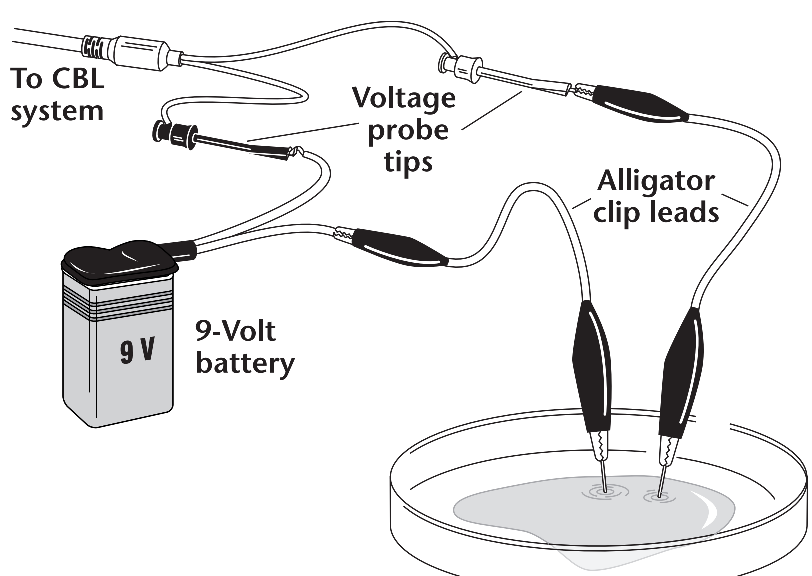


Figure 1

Safety

Wear goggles and an apron at all times. Be cautious when using 1*M* HCl. If any acid touches your skin or eyes, immediately rinse with water and notify your teacher. Never test chemicals by tasting.

PROCEDURE

1. Set up the voltage system for data collection by plugging the voltage probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Attach the 9-Volt battery clip to the battery. Hook the black probe tip (negative) of the voltage probe to the black wire (negative) of the battery clip. Attach an alligator clip to the red (positive) wire of the battery clip. Attach the second alligator clip to the red (positive) voltage probe tip. Bend the free end of the paper clips so that one part projects. Attach an alligator clip to each paper clip. Figure 1 shows the alligator clips with paper clips.
3. Use the table provided for your data and observations.
4. Observe and record the appearance of each of the 14 samples of elements. Your description should include physical state, color, and any other observable characteristics such as luster. Do not open any of the test tubes.
5. Remove a small sample of each of the six elements in the dishes. Place the samples on a hard surface designated by your teacher. Gently tap each of the elements with a small hammer. An element is malleable if it flattens when tapped. It is brittle if it shatters when tapped. Record your observation in the data table.
6. Turn on the CBL System and graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
7. Select SET UP PROBES from the MAIN MENU. Enter “1” as the number of probes. On the SELECT PROBES MENU, chose VOLTAGE. Enter “1” as the channel number. Next select COLLECT DATA from the MAIN MENU. On the DATA COLLECTION menu, select MONITOR INPUT.
8. Touch the two paper clips together and observe the reading on the CBL System or graphing calculator. A good 9-Volt battery should read close to 9-Volts. This is the reading you should expect to have when testing materials that are good conductors. A reading of a volt or two below the battery voltage indicates a poor conductor. With the leads separated in the air observe the reading. This reading will be the typical reading for non-conductors.
9. Test the conductivity of each of the six elements in the dishes by touching the paper clips to one of the elements. Take several readings and record your measurements. Indicate whether the element is a conductor or non-conductor.

10. Use a graduated cylinder to measure 5 mL of water into each of the six test tubes.
11. Label each test tube with the symbol of one of the six element samples in the dishes.
12. Using a spatula, put a small sample of each of the six elements (a 1-cm length of ribbon or 0.1–0.2 g of solid) into a test tube labeled with the symbol of the element. Wash and dry the spatula between samples.
13. Add approximately 5 mL of 1*M* HCl to each of the test tubes, and observe the samples for at least one minute. Evidence of a reaction is the formation of bubbles of hydrogen on the sample. Record your observations in the data table.

ANALYZE AND CONCLUDE

1. **Interpreting Data** Which elements displayed the general characteristics of metals?
2. **Interpreting Data** Which elements displayed the general characteristics of non-metals?
3. **Interpreting Data** Which elements displayed a mixture of metallic and non-metallic characteristics?

APPLY AND ASSESS

1. Construct an abbreviated periodic table with seven 1-inch squares across and five squares down. Label the squares across the top from left to right as Groups 1 and 2 and 13–17. Label the squares down the side as Periods 2–6. Write the appropriate atomic number and element symbol in each square. Based upon your answers to the Analyze and Conclude questions, write your classification of the metal, nonmetal, or metalloid for each of the elements you observed and/or tested.
2. Do the metallic characteristics of the elements across a period seem to increase from left to right or from right to left?
3. Do the metallic characteristics of the elements in a group seem to increase from top to bottom or from bottom to top?
4. The metalloids indicate the approximate border between metals and nonmetals on the periodic table. Based upon your observations, draw a dark line along this border.

DATA AND OBSERVATIONS

Element	Appearance	Malleable or Brittle	Electrical Conductivity	Reaction with HCl
carbon				
magnesium				
aluminum				
silicon				
sulfur				
tin				
nitrogen				
oxygen				
red phosphorous				
chlorine				
calcium				
selenium				
iodine				
lead				

Name

Date Class

The Formation and Decomposition of Zinc Iodide

Experiment 2
Use with ChemLab 4 pages 136–137

Problem

Can a compound be synthesized from its elements and then decomposed back into its original elements?

Objectives

- **Compare** a compound with its component elements.
- **Observe** and monitor a chemical reaction.
- **Observe** the decomposition of the compound back to its elements.

PREPARATION

Materials

10 × 150-mm test tube
plastic stirring rod
zinc
test-tube holder
test-tube rack
iodine crystals
100-mL beaker
distilled water
CBL System
TI Graphing Calculator with unit-to-unit link cable
temperature probe
9-V battery with terminal clip and leads
two 20-cm insulated copper wires stripped at least 1 cm on each end
CBL AC adapter (optional)

Safety

Iodine crystals are toxic and can stain the skin. Use care when using solid iodine. The reaction of zinc and iodine releases heat. Always use the test-tube holder to handle the reaction test tube.

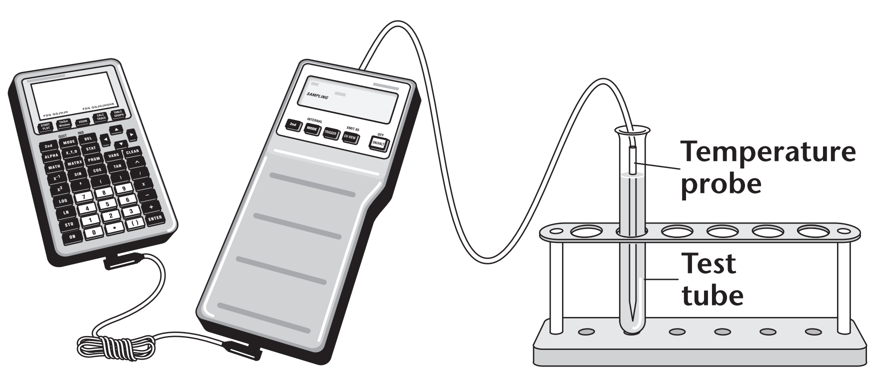
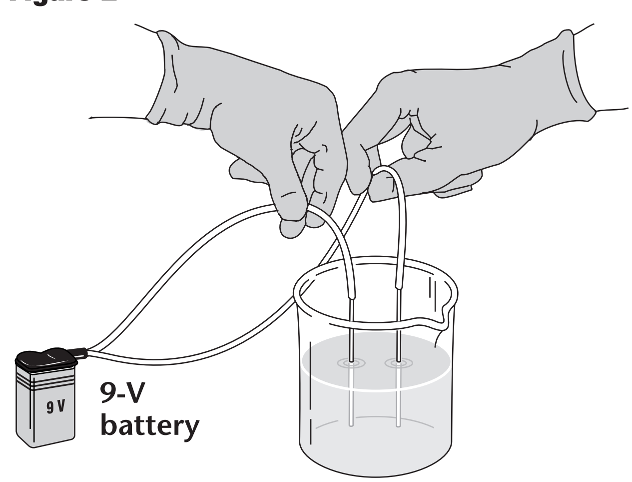


Figure 1

PROCEDURE

1. Plug the temperature probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
3. Select SET UP PROBES from the MAIN MENU. Enter “1” as the number of probes. On the SECLECT PROBES menu select temperature. Enter “1” as the channel number.
4. The MAIN MENU will reappear. Select COLLECT DATA.
5. Obtain a test-tube holder and a small beaker. Place the test tube upright in a test-tube rack.
6. Carefully add approximately 1 g of zinc dust and about 10 mL of distilled water to the test tube.
7. Place the temperature probe in the test tube. On the graphing calculator display under DATA COLLECTION, select MONITOR INPUT. Record the starting temperature of the test tube contents.
8. Carefully add about 1 g of iodine to the test tube. Record your observations.
9. Stir the contents of the test tube thoroughly with a plastic stirring rod until there is no more evidence of a reaction. Record any observations of physical or chemical changes. Note the highest temperature reading on the graphing calculator.
10. Allow the reaction mixture to settle. Using a test-tube holder, carefully pick up the test tube and pour off the solution phase into the small beaker.
11. Add water to the beaker to bring the volume up to about 25 mL.
12. Obtain a 9-V battery with wire leads and two pieces of copper wire. Attach the copper wires to the wire leads from the battery. Make sure that the wires are not touching each other.
13. Dip the wires into the solution in the beaker and observe what takes place. Record your observations.
14. After two minutes, remove the wires from the solution and examine the wires. Record your observations.

Figure 2



ANALYZE AND CONCLUDE

1. **Observing and Inferring** What evidence was there that a chemical reaction occurred?
2. **Comparing and Contrasting** How did you know the reaction was complete?
3. **Making Inferences** What term is used to describe a reaction in which heat is given off? How can you account for the heat given off in this reaction?
4. **Checking Your Hypothesis** What evidence do you have that the compound was decomposed by electrolysis?
5. **Drawing Conclusions** Why do you think the reaction between zinc and iodine stopped?

APPLY AND ASSESS

1. What role did the water play in this reaction?
2. Do you think zinc iodide is an ionic or covalent compound? What evidence do you have to support your conclusion?
3. The formula of zinc iodide is ZnI_2. Use Lewis dot structures to show how it forms from its elements. Hint: Zinc atoms have two valence electrons.

DATA AND OBSERVATIONS

Temperature of water before reaction: ______________________

Temperature (maximum) of water after zinc and iodine reaction: ______________________

Step	Observations
8. Addition of iodine to zinc	
9. Reaction of iodine and zinc	
13. Electrolysis of solution	
14. Examination of wires	

Name

Date Class

Ionic or Covalent

Experiment 3
Use with ChemLab 5 pages 172–173

Problem

How can you identify ionic and molecular compounds by their properties?

Objectives

- **Examine** the properties of several common substances.
- **Interpret** the property data to classify each substance as ionic or molecular.

PREPARATION

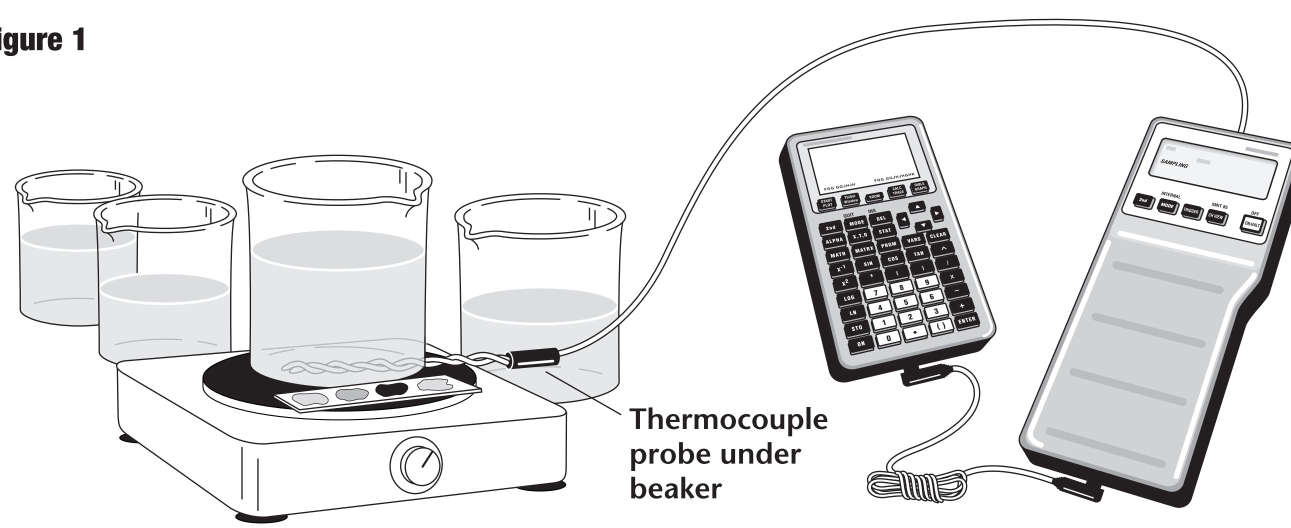
Materials

glass microscope slide
grease pencil or crayon
hot plate
spatula
4 small beakers (50- or 100-mL)
stirring rod
balance
graduated cylinder, small
1- to 2-g samples of any 4 of the following: salt substitute (KCl), fructose, aspirin, paraffin, urea, table salt, table sugar, Epsom salt
CBL System
TI Graphing Calculator with unit-to-unit link cable
thermocouple probe
conductivity tester
CBL AC adapter (optional)

Safety

Use care when handling hot objects.

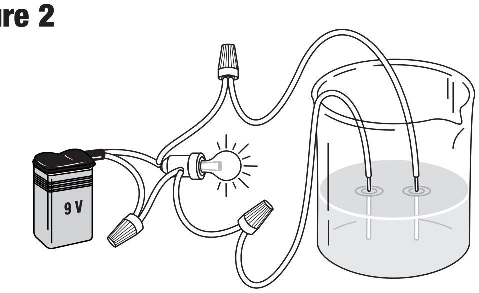
Figure 1



PROCEDURE

1. Plug the thermocouple probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
3. Select SET UP PROBES from the MAIN MENU. Enter "1" as the number of probes. Under the SECLECT PROBES menu select MORE PROBES. Then select MORE PROBES again. Choose THERMOCOUPLE. Enter "1" as the channel number. Under CALIBRATION, select USE STORED.
4. The MAIN MENU will reappear. Select COLLECT DATA.
5. Use a grease pencil or crayon to draw lines dividing a glass slide into four parts. Label the parts A, B, C, and D.
6. Use a spatula to place about 0.1 to 0.2 g of the first of your four substances on section A of your slide.
7. Repeat step 6 with your other three substances on sections B, C, and D. Be sure to clean your spatula after each sample. Record in the data table provided which substance was put in each section.
8. Place the slide on the hot plate. Lay the wires of the thermocouple directly on the hot plate and hold them in place with a beaker half-full of water. This will ensure good heat transfer to the thermocouple. On the graphing calculator display under DATA COLLECTION, select MONITOR INPUT. Turn the heat setting to medium and begin to heat the slide.
9. Continue heating until the temperature of the hot plate and slide reaches 135°C. Observe each section on the slide, and record in your data table which substances have melted. Turn the hot plate off. Turn off the CBL System and the graphing calculator.
10. Label four beakers with the names of your four substances.
11. Weigh equal amounts of the four substances (1–2 g of each), and place the weighed samples in their labeled beakers.
12. Add 10 mL of distilled water to each beaker
13. Stir each substance, using a clean stirring rod for each sample. Note in your data table whether or not the sample dissolved completely.
14. Test each substance for the presence of electrolytes by using a conductivity tester. Record whether or not each acts as a conductor.

Figure 2



ANALYZE AND CONCLUDE

1. **Interpreting Observation** What happened to the bonds between the molecules when a substance melted?
2. **Comparing and Contrasting** Did all the compounds melt at the same temperature?
3. **Classifying** Complete your data table by classifying each substance you tested as ionic or molecular compounds based on your observation.

APPLY AND ASSESS

1. What are the differences in properties between ionic and molecular compounds?
2. How did the melting points of the ionic compounds and the molecular compounds compare? What factors affect melting points?
3. The solutions of some molecular compounds are good conductors of electricity. Explain how this can be true when ions are required to conduct electricity?
4. Consider a mixture of sand, salt, and water. How can you make use of the differences in properties of these materials to separate them?

DATA AND OBSERVATIONS

Substance	Did it melt?	Did it dissolve in water?	Did the solution conduct electricity?	Classification
A				
B				
C				
D				

Name

Date Class

Molecules and Energy

Experiment 4
Use with ChemLab 10 pages 362–363

Problem
How does energy transferred to or from a molecular substance affect the average kinetic energy of its molecules?

Objectives
- **Observe** the temperature changes and changes of state when a molecular substance is heated and cooled.
- **Make and use graphs** to analyze temperature changes.
- **Interpret** temperature changes in terms of the changes in average kinetic energy of a substance's molecules.

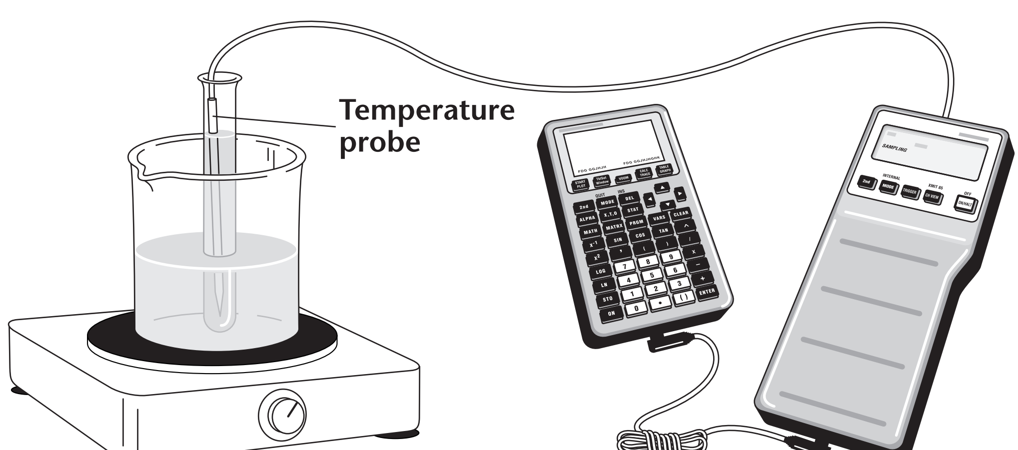
PREPARATION

Materials
hot plate
20 × 150 mm test tube
test-tube holder
400-mL beakers (2)
beaker tongs
clamp and ring stand
stearic acid
CBL System
TI Graphing Calculator with unit-to-unit link cable
temperature probe
stopwatch or timing-device
CBL AC adapter (optional)

Safety


Use beaker tongs when handling the beaker of hot water and a test-tube holder when handling the hot test tube.

Figure 1



PROCEDURE

1. Plug the temperature probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
3. Select SET UP PROBES from the MAIN MENU. Enter "1" as the number of probes. On the SECLECT PROBES menu select temperature. Enter "1" as the channel number.
4. The MAIN MENU will reappear. Select COLLECT DATA.
5. Use the two data tables provided to record your data.
6. Pour 300 mL of tap water into a 400-mL beaker and place the beaker on a hot plate.
7. Place the temperature probe in the beaker of water. On the graphing calculator display under DATA COLLECTION, select MONITOR INPUT. Turn on the heat and monitor the water temperature until it reaches 90°C. Maintain the water temperature at 90°C by using the heat control of the hot plate or by adding cold water.
8. Half fill the test tube with stearic acid. Remove the temperature probe from the water and wipe the probe to remove water from it. Insert the temperature probe into the stearic acid. After the temperature of the probe has adjusted to the temperature of the stearic acid, record this temperature on the first line of the *Heating Data* table.
9. Attach the clamp to the test tube and immerse the test tube in the beaker of hot water. Read and record the temperature and the physical state or states of the stearic acid every 30 seconds until all of the material has melted and its temperature is about 80°C.
10. Pour 300 mL of cold tap water into the second 400-mL beaker.
11. Remove the test tube with the temperature probe and contents from the first beaker and immerse it in the cold water in the second beaker. Read and record in the *Cooling Data* table the temperature and physical state or states of the stearic acid every 30 seconds until the material has solidified. Turn the calculator and CBL system off.

ANALYZE AND CONCLUDE

1. **Making graphs** Graph the heating data by plotting temperature readings on the vertical axis and time on the horizontal axis. Connect the data points with straight lines or smooth curves. Label the appropriate segments of the graph *solid, solid and liquid,* or *liquid.* Graph the cooling data in the same way.
2. **Interpreting Data** Divide each graph into three intervals by drawing two vertical lines at the points where the slope of the graph changes. Label the intervals of the first graph A, B, and C and those of the second graph D, E, and F.
3. **Drawing Conclusions** According to your data, what is the approximate melting point of stearic acid?
4. **Relating Concepts** Describe how the kinetic energy of the stearic acid molecules changed during each interval.

APPLY AND ASSESS

1. Describe how the molecular motion changed during each segment of the heating and cooling curves.

2. Suppose twice as much stearic acid was used. What would the graph look like? Make a sketch.

DATA AND OBSERVATIONS

Heating Data

Elapsed Time (s)	Temperature (°C)	Physical State
0		
30		
60		
90		
120		
150		
180		
210		
240		
270		
300		
330		
360		
390		
420		
450		
480		
510		
540		
570		
600		

Cooing Data

Elapsed Time (s)	Temperature (°C)	Physical State
0		
30		
60		
90		
120		
150		
180		
210		
240		
270		
300		
330		

Name ______________________________

Date ______________ Class ______________

Boyle's Law

Experiment 5

Use with ChemLab 11 pages 384–385

Problem

What is the relationship between the volume and the pressure of a gas at constant temperature?

Objectives

- **Observe** the length of a column of trapped air at different pressures.
- **Examine** the mathematical relationship between gas volume and gas pressure.

PREPARATION

Materials

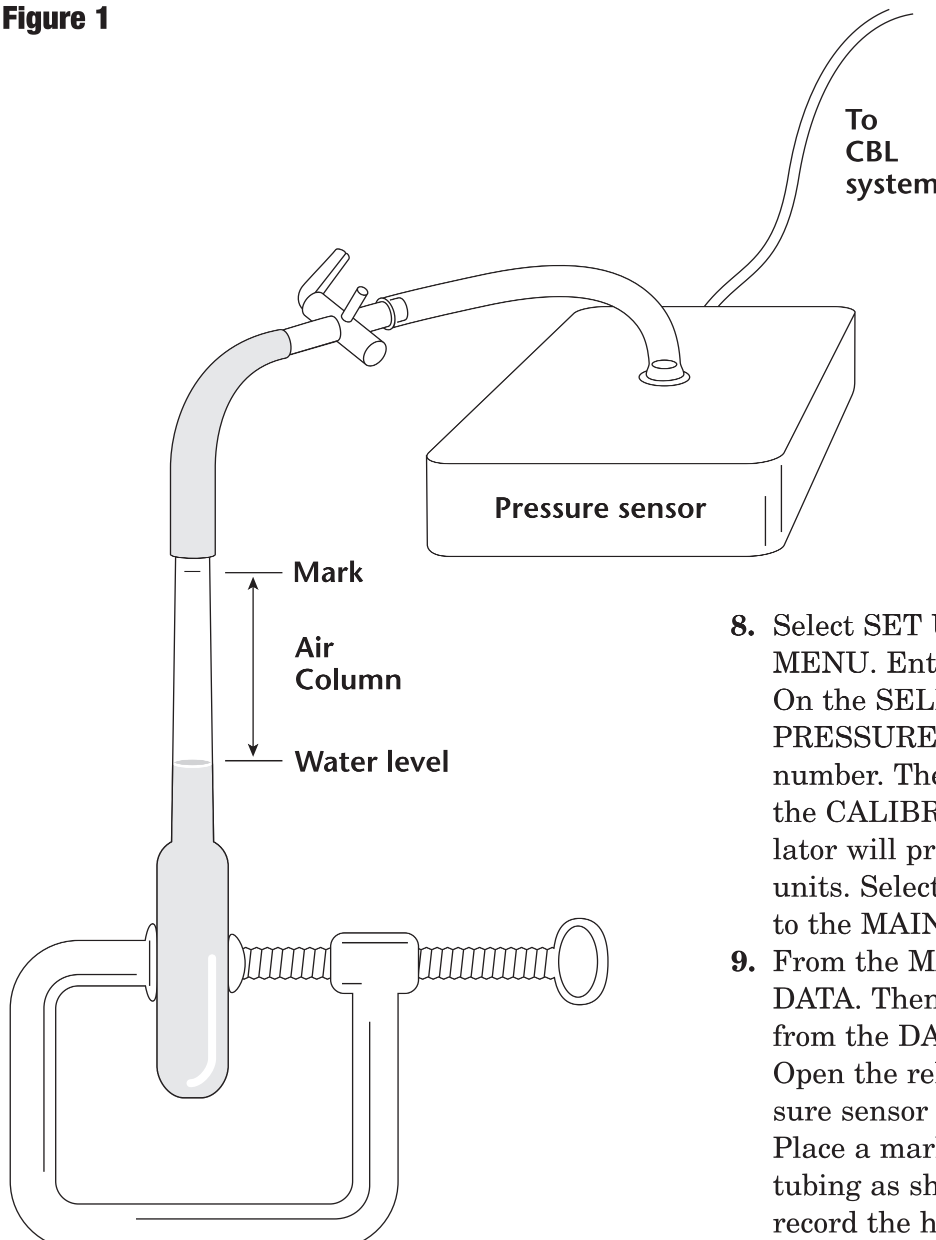
thin-stem pipet
double-post screw clamp
fine-tip marker
food coloring
20 cm of flexible tubing
metric ruler
scissors
100-mL beaker
water
CBL System
TI Graphing Calculator with unit-to-unit link cable
CBL DIN adapter
pressure sensor
CBL AC adapter (optional)

Safety

PROCEDURE

1. Set up the pressure sensor for data collection by plugging the pressure sensor into the DIN adapter and then into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Cut off the stepped portion of the stem of the pipet with the scissors.
3. Place about 20-mL of water in the beaker, add a few drops of food coloring, and swirl to mix.
4. Draw the water into the pipet, completely filling the bulb and allowing the water to extend about 5 mm into the stem of the pipet.
5. Slide the piece of flexible tubing over the end of the pipet. Make sure you have a tight connection. Center the bulb in the double-post screw clamp, and tighten the clamp until the bulb is just held firmly.
6. Attach the other end of the tubing to the three-way valve on the pressure sensor. Position the pressure sensor so that it does not put a strain on the pipet. **Caution:** *Do not allow water up into the pressure sensor.*
7. Turn on the CBL System and the TI Graphing Calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from our Apple Macintosh or PC computer to your graphing calculator.

Figure 1



8. Select SET UP PROBES from the MAIN MENU. Enter "1" as the number of probes. On the SELECT PROBES menu, choose PRESSURE. Enter "1" as the channel number. Then select USE STORED from the CALIBRATION menu. Next the calculator will prompt you for the pressure units. Select MM HG. You will be returned to the MAIN MENU.
9. From the MAIN MENU, select COLLECT DATA. Then select MONITOR INPUT from the DATA COLLECTION menu. Open the release valve to expose the pressure sensor port to atmospheric pressure. Place a mark on the pipet just below the tubing as shown in Figure 1. Measure and record the height in mm of the air column between the water and the mark. Record the pressure. Close the release valve.
10. Turn the clamp knob one complete turn, and record the trial number and total number of turns. Measure and record the length of the air column and the pressure reading.
11. Repeat step 10 until the height of the air column is reduced by 25 to 30 mm.

ANALYZE AND CONCLUDE

1. **Observing and Inferring** Explain whether volume (V) of air in the stem is directly proportional to the length (L) of the air column. What inferences can be made about the pressure (P) of the air column and the length of the air column?
2. **Interpreting Data** Calculate the product (LP) and quotient (L/P) for each trial. Which calculation is more consistent? If L and P are directly related, L/P will yield nearly constant values for each trial. On the other hand, if L and P are inversely related, LP will yield almost constant values for each trial. Are L and P directly or inversely related?
3. **Drawing Conclusions** Explain whether the data indicate that gas volume and gas pressure at constant temperature are directly related or inversely related.

DATA AND OBSERVATIONS

Pressure and Length Data

Trial	Turns, *T*	Length of Air Column, *L* (mm)	Pressure *P* (mm Hg)	Numerical Value, *LT*	Numerical Value, *L/T*

APPLY AND ASSESS

1. For a mercury column barometer to measure atmospheric pressure as 760 mm Hg, the column containing the mercury must be completely evacuated. However, if the column is not completely evacuated, the barometer can still be used to correctly measure *changes* in barometric pressure. How is the second statement related to Boyle's law?
2. Using the kinetic theory, explain how a decrease in the volume of a gas causes an increase in the pressure of the gas.

Name

Date Class

Household Acids and Bases

Experiment 6
Use with ChemLab 14 pages 504–505

Problem

What are the approximate pH values for various household liquids?

Objectives

- **Measure** and **compare** the pH values for various household liquids.
- **Compare** the functions of liquids with their chemical makeup.

PREPARATION

Materials

100-mL beaker
distilled water
rinse bottle of distilled water
microtip pipets (8)
24-well microplate
solutions of:
 eyewash
 baking soda
 lemon juice
 borax
 white vinegar
 drain cleaner
 table salt
 soap
CBL System
TI Graphing Calculator with unit-to-unit link cable
DIN adapter cable
pH probe—amplifier and probe
CBL AC adapter (optional)

Safety

Wear an apron and safety goggles. Some of the solutions to be tested are caustic, especially the drain cleaner. Avoid all contact with skin and eyes. If contact occurs, immediately wash with large amounts of water and notify the teacher.

PROCEDURE

1. Using a clean pipet for each solution, add 25 drops of eyewash to well A1, lemon juice to B1, white vinegar to C1, and solution of table salt to D1, soap to A6, baking soda to B6, borax to C6, and drain cleaner to D6. Set the 24-well microplate aside for now.
2. Set up the pH system for data collection by plugging the pH amplifier into the DIN adapter and then into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
3. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.

4. Select SET UP PROBES from the MAIN MENU. Enter “1” as the number of probes. On the SELECT PROBES menu select PH. Enter “1” as the channel number. Then select USE STORED from the CALIBRATION MENU. After selecting USE STORED you will be returned to the MAIN MENU.
5. From the MAIN MENU, select COLLECT DATA. On the DATA COLLECTION menu, select MONITOR INPUT. After this selection the calculator will display a message reminding you to allow the system to warm up for 30 seconds and then press ENTER. Since the CBL System will automatically power down after periods of time it is important to follow this reminder. A screen message stating that the calculator is monitoring the active channel will be displayed along with the pH value which is also visible on the CBL System screen.
6. Before each use of the pH probe, rinse the tip of the electrode completely with distilled water. Carefully hold the pH probe over a beaker and gently rinse the tip with distilled water. **Caution:** *The tip of the pH probe is fragile and can be broken easily.* Do not let the probe dry out. When it is not in use during the lab, keep the probe immersed in a beaker of tap water.
7. Carefully remove the pH probe from the tap water beaker and place it into well A1. Figure 1 shows a sample setup with the pH probe inserted into cell C1. Allow the pH value reading to stabilize for 15–20 seconds. Record your data in the table provided.
8. Carefully rinse the electrode tip with distilled water by holding the pH electrode over a rinse beaker and use the rinse bottle to rinse the electrode tip. Repeat step 7 for all eight wells. Record your data and rinse the electrode between each use.

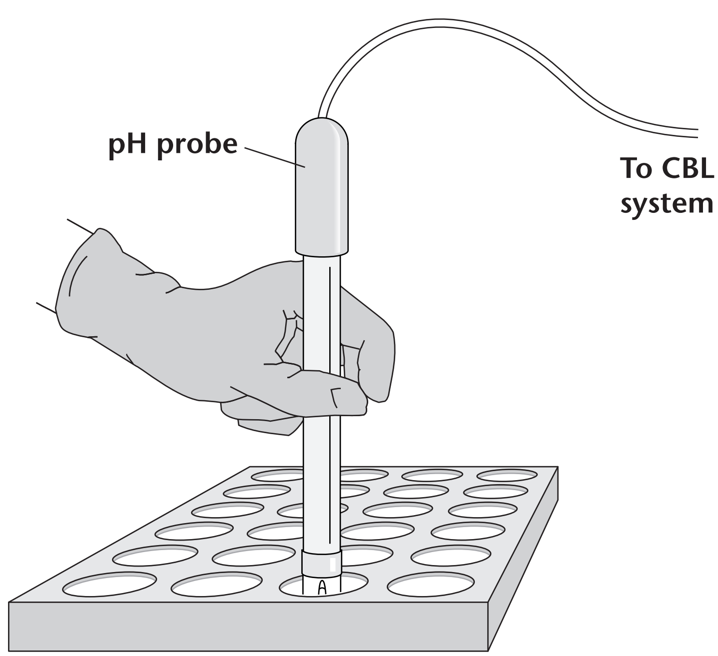


Figure 1

ANALYZE AND CONCLUDE

1. **Interpreting Data** Are foods items such as lemon juice or vinegar acidic or basic? These solutions are either tart or sour, so what ion probably accounts for this characteristic?
2. **Interpreting Data** Were the cleaning solutions acidic or basic? What ion is probably involved in the cleaning process?
3. **Observing and Inferring** How do you account for the great pH difference between lemon juice (citric acid solution) and eyewash (boric acid solution)?
4. **Using Variables, Constants, and Controls** Suppose that, in addition to the solutions, you tested a well containing pure distilled water. What purpose would this test serve?

APPLY AND ASSESS

1. You may have noted that some shampoos are described as pH-balanced. What do manufacturers mean by this phrase? Why would they do this to a soap or detergent?
2. Hypothesize about the pH of other solutions at home.

DATA AND OBSERVATIONS

Solution	pH
Eyewash	
Lemon juice	
White Vinegar	
Table salt	
Soap	
Baking soda	
Borax	
Drain cleaner	

Name

Date Class

Titration of Vinegar

Experiment 7
Use with ChemLab 15 pages 542–543

Problem

What are the volume percentages of acetic acid in several brands of vinegar?

Objectives

- **Observe** acid-base titrations of several vinegars with a standard sodium hydroxide solution.
- **Calculate** the volume percentages of acetic acid in the vinegars.
- **Compare** the acetic acid concentrations of various brands of vinegar.

PREPARATION

Materials

24-well microplate
several brands of vinegar
labeled microtip pipets
standard NaOH solution
toothpicks
distilled water in a wash bottle
beaker
TI Graphing Calculator with unit-to-unit link cable
CBL System
DIN adapter
pH probe—amplifier and probe
CBL AC adapter (optional)

Safety

Wear an apron and safety goggles. Sodium hydroxide is caustic and can damage skin and eyes. If you come into contact with any of this solution, rinse the affected area with a large volume of water and notify the teacher. Wash hands thoroughly when you complete the lab.

PROCEDURE

1. Set up the pH system for data collection by plugging the pH amplifier into the DIN adapter and then into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
3. Select SET UP PROBES from the MAIN MENU. Enter “1” as the number of probes. On the SELECT PROBES menu, select PH. Enter “1” as the channel number. Then select USE STORED from the CALIBRATION MENU. After selecting USE STORED you will be returned to the MAIN MENU.

4. From the MAIN MENU, select COLLECT DATA. On the DATA COLLECTION menu, select MONITOR INPUT. After this selection the calculator will display a message reminding you to allow the system to warm up for 30 seconds and then press ENTER. Since the CBL System will automatically power down after periods of time it is important to follow this reminder. A screen message stating that the calculator is monitoring the active channel will be displayed along with the pH value, which is also visible on the CBL System screen.
5. Before each use of the pH probe, rinse the tip of the electrode completely with distilled water. Carefully hold the pH probe over a beaker and gently rinse the tip with distilled water. **Caution:** *The tip of the pH probe is fragile and can be broken easily.* Do not let the probe dry out. When it is not in use during the lab, keep the probe immersed in a beaker of tap water.
6. Use a microtip pipet to add 10 drops of one type of vinegar to each of wells A1, B1, and C1 of the microplate. Record the brand of vinegar in the data table.
7. Carefully remove the pH probe from the tap water beaker and place it into well A1. Figure 1 shows a sample setup with the pH probe inserted into cell C1. Allow the pH value reading to stabilize for 15–20 seconds. Record your data in the table provided.
8. Use a clean pipet to carefully add a drop of standard NaOH solution to well A1, stir with a toothpick, and take 10 readings. Repeat this process, counting the drops, until there is a sharp jump taking the pH reading above 7.0. This is the endpoint. Continue adding drops of NaOH until the pH reads 8.8. Rinse the pH probe in distilled water and place it in a beaker of water. Record the number of drops needed to reach the end point.
9. Repeat step 8 for well B1. If the result differs by more than one drop from that of the first titration, repeat again with the sample in well C1.
10. Repeat steps 6 through 9 with the other brands of vinegar using the other columns of the microplate. Record your data after each titration.
11. Rinse the pH probe and dismantle the equipment as directed by your teacher.

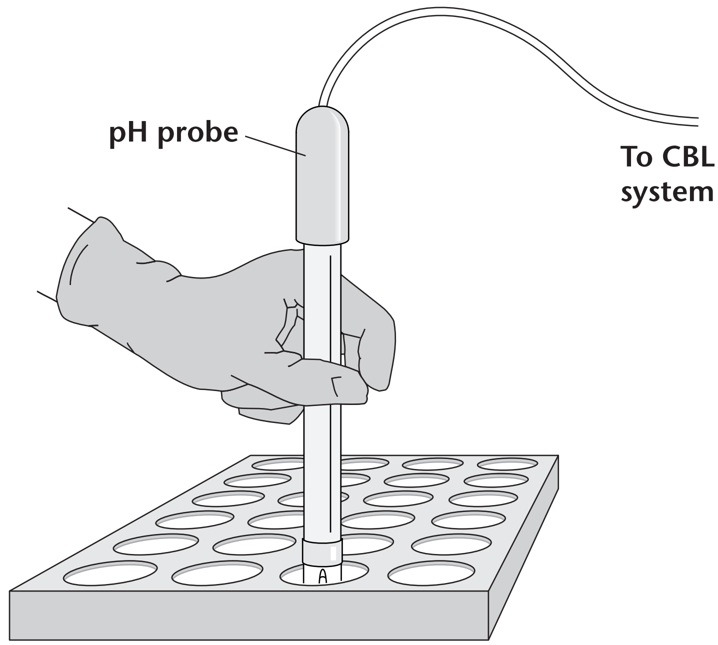


Figure 1

ANALYZE AND CONCLUDE

1. **Interpreting Data** From the two closest trials, find the average number of drops of NaOH required to titrate each vinegar. Use the average number of drops and the given molarity of NaOH to calculate the molarity of acetic acid in each brand of vinegar. Assuming identical volumes for drops of vinegar and drops of NaOH solution, the ratio of reacting volumes in liters is the same as the ratio of reacting volumes in drops.
2. **Interpreting Data** Use your results to calculate the volume percentage of acetic acid in each brand of vinegar according to the formula: M acetic acid $\times$ (1.00 percent acetic acid/0.175M acetic acid) = percent acetic acid by volume.
3. **Comparing and Contrasting** Which of the brands of vinegar you tested contained the highest volume percent of acetic acid?

APPLY AND ASSESS

1. How could you have changed the experimental procedure in order to more accurately determine the concentrations of the vinegars?
2. If the cost and volume of each brand of vinegar are available, calculate the cost per percent of acetic acid per unit volume for each. Which is the best buy based on this criterion?

DATA AND OBSERVATIONS

Type of Vinegar	Trial 1—Drops of NaOH	Trial 2—Drops of NaOH	Trial 3—Drops of NaOH
Brand A			
Brand B			
Brand C			
Brand D			

Name ______________________

Date ____________ Class ____________

Oxidation-Reduction and Electrochemical Cells

Experiment 8

Use with ChemLab 17 pages 606–607

Problem

How may a spontaneous redox reaction be used to construct an electrochemical cell?

Objectives

- **Observe** a simple oxidation-reduction reaction.
- **Relate** the reaction to the oxidation tendencies of the reactants.
- **Utilize** the reaction to construct an electrochemical cell that can operate electrical devices.

PREPARATION

Materials

craft-stick support with V-cut and slit cut
25-mm (flat diameter) dialysis tubing (15 cm in length)
magnesium ribbon (10 cm in length)
magnesium ribbon (1 cm in length)
copper foil (10 cm × 1 cm strip)
metric ruler
250-mL beaker
wire leads with alligator clips (7)
10 × 100 mm test tubes
flashlight bulb: 3-V type for a 2 cell lamp
walkman radio
0.5*M* sodium chloride solution
0.5*M* copper(II) chloride solution
0.1*M* magnesium chloride
TI Graphing Calculator with unit-to-unit link cable
CBL System
voltage probe
CBL AC adapter (optional)

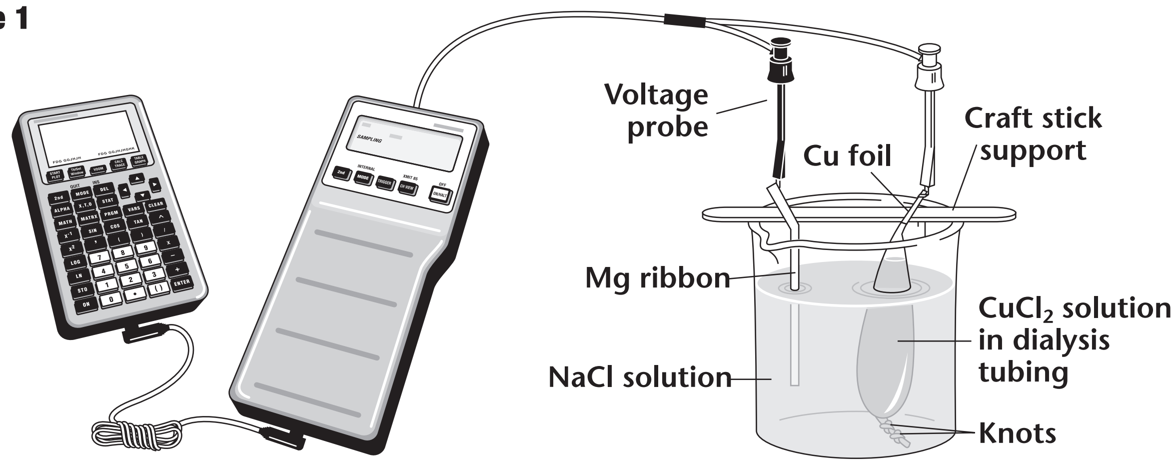
Safety

Wear an apron and safety goggles. Rinse the solutions down the drain with large amounts of tap water. Wash your hands after performing the lab.

PROCEDURE

1. Soak the dialysis tubing in tap water for about ten minutes while you complete steps 2 and 3.
2. Pour a small amount of copper(II) chloride solution in the 10 × 100 mm test tube, and drop a 1-cm length of magnesium ribbon into the solution. Observe the system for about one minute, and record your observations in the data table provided under Data and Observations. After completing this, pour this solution down the drain and discard the magnesium strip in the wastebasket.
3. Repeat step 2 using magnesium chloride solution and the small piece of the copper foil.
4. Tie two knots near one end of the dialysis tubing and open the other end by sliding the material between your fingers. Pour copper(II) chloride solution into the open end of the tubing to a depth of 6 cm to 8 cm, and insert the strip of copper foil. Slide the top of the tubing and copper strip into the V-cut in the stick as shown in Figure 1. Suspend the tubing in the beaker.
5. Slide the length of magnesium ribbon into the slit cut in the craft stick, as shown.

Figure 1



6. Pour about 200 mL of sodium chloride solution into the beaker.
7. Plug the voltage probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and the TI Graphing Calculator. Push the link cable securely into each jack.
8. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow the instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
9. Select SET UP PROBES from the MAIN MENU. Enter "1" as the number of probes. On the SELECT PROBES menu select voltage. Next, enter "1" as the channel number.
10. The MAIN MENU will reappear. Select COLLECT DATA. On the DATA COLLECTION menu, select MONITOR INPUT.
11. On the voltage probe, hook up the red (+) probe clip to the Cu electrode and the black (–) probe clip to the Mg electrode. Read and record the potential difference or voltage. Press + on the calculator to stop data monitoring.
12. Cooperate with other lab groups in the following way to light the light bulb, see Figure 2, and to operate the walkman radio, see Figure 3. The light bulb requires about 2.5–3 Volts to light and the walkman radio requires a similar potential. One may work while the other does not. The light bulb may require more charge than the radio and the cells may not produce a sufficient amount. The voltage recorded from step 11 is the voltage produced by one cell. Cells connected in series are additive, that is their voltage will be the sum of each individual cell. Connect the appropriate number of individual electrochemical cells in series (copper to magnesium) to provide the desired voltage.
13. In the series of cells connected to the light bulb measure the voltage generated. Press ON again on both the CBL System and graphing calculator if the screen has gone blank; the equipment powers itself down after several minutes of non-use to conserve battery power. Press COLLECT DATA and MONITOR INPUT. Have your lab partner hold the light bulb steady and touch the leads of the cell to the bulb. Touch one lead to the circular metal case surrounding the bulb and one lead to the small dull metal tip in the middle of the bulb base. What voltage did you observe?

14. Replace the light bulb with the Walkman radio. Locate the positive terminal, where the tip of the battery goes, and locate the negative terminal, where the base of the second battery goes. The voltage should be between 2.5–3.5 volts. Increase or decrease the number of cells so the voltage falls in this range. Turn on the radio and tune in your favorite station.

15. Turn off the CBL System and graphing calculator. Disassemble your cells, observing the pieces of copper and magnesium. Record your observations. Rinse the pieces of copper and magnesium, and dispose of them according to instructions from your teacher.

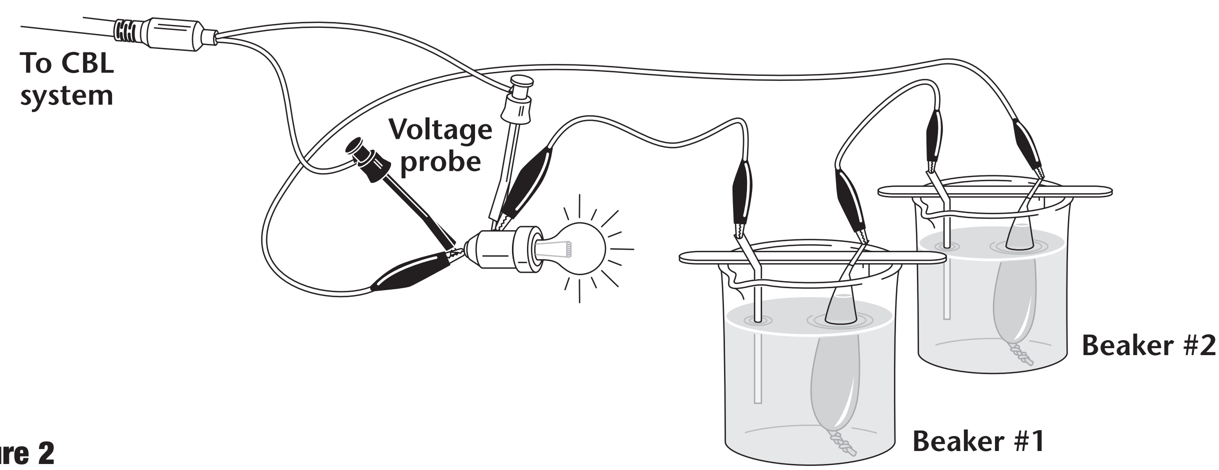


Figure 2

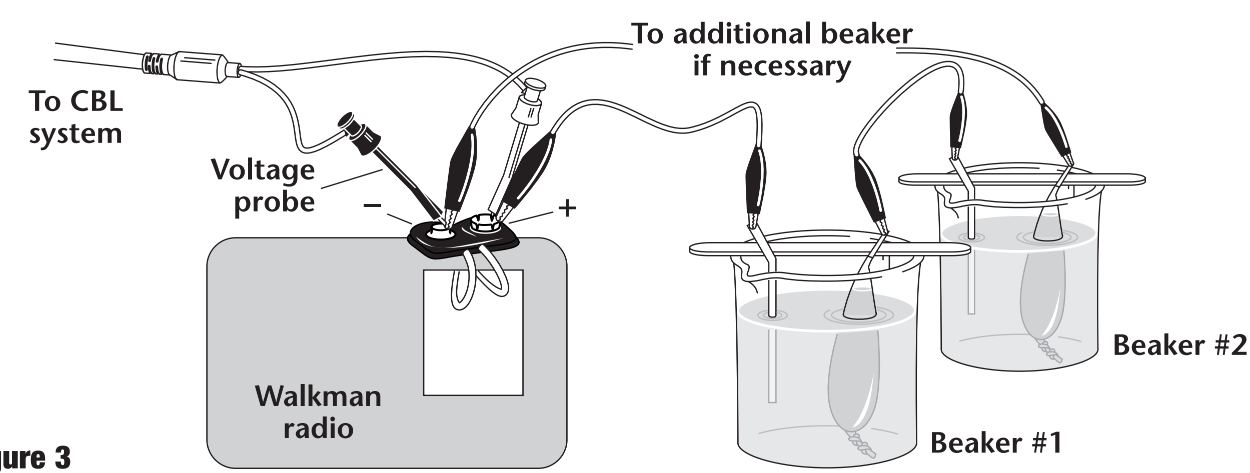


Figure 3

ANALYZE AND CONCLUDE

1. **Interpreting Data** Write the balanced equation for the single-replacement reaction between magnesium and copper(II) chloride that occurred in step 2. Which metallic element, Cu or Mg, has the greater tendency (or oxidation potential) to lose electrons?
2. **Relating Concepts** In an electrochemical cell, oxidation occurs at the anode, and reduction occurs at the cathode. Which metal was the anode and which metal was the cathode? Write the equations for the half-reactions.

APPLY AND ASSESS

1. When an electrochemical cell is used to operate an electrical device, in which direction do electrons move in the external circuit?
2. Is it possible to construct an electrochemical cell in which lead (Pb) is the anode and lithium (Li) is the cathode? Explain.

DATA AND OBSERVATIONS

	Data and Observations
$Mg - Cu^{2+}$	
$Cu - Mg^{2+}$	
Voltage	
Pieces of Cu and Mg	

Name

Date Class

Catalytic Decomposition—It's in the Cells

Experiment 9
Use with ChemLab 19 pages 674–675

Problem
How does temperature affect the catalytic decomposition of hydrogen peroxide by catalase from carrot cells?

Objectives
- **Observe** the action of catalase on the decomposition of hydrogen peroxide.
- **Compare** the rate of reaction at various temperatures.
- **Make and use** graphs to interpret results

PREPARATION

Materials
hot plate
small (13 × 100 mm), clean, unscratched test tubes (8)
test-tube rack
small beakers (4)
carrot-cell slurry
3% hydrogen peroxide solution
crushed ice
10-mL graduated cylinder
metric ruler
glass stirring rod
thermal glove
marking pencil
CBL System
TI Graphing Calculator with unit-to-unit link cable
temperature probe
stopwatch or timing device
CBL AC adapter (optional)

Safety


Wear safety goggles and an apron. Wear thermal gloves when handling hot items. Hydrogen peroxide can harm the eyes

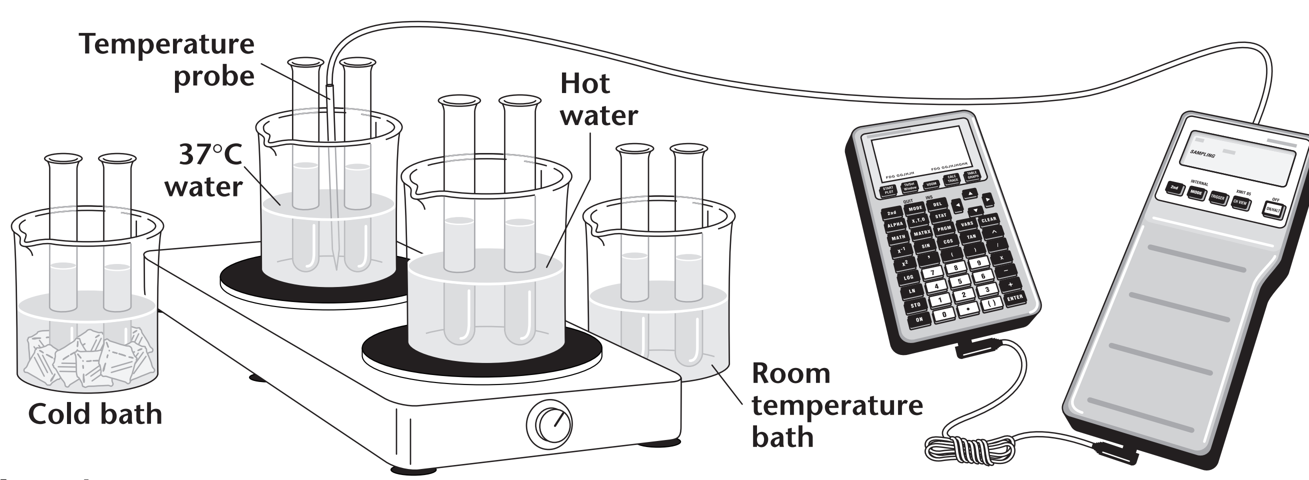


Figure 1

PROCEDURE

1. Plug the temperature probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
3. Select SET UP PROBES from the MAIN MENU. Enter "1" as the number of probes. On the SECLECT PROBES menu select temperature. Enter "1" as the channel number.
4. The MAIN MENU will reappear. Select COLLECT DATA.
5. Place carrot-cell slurry into each of four test tubes to a depth of about 2 cm.
6. Carefully measure 3.0 ml of 3% hydrogen peroxide solution into each of another four test tubes. If large quantities of bubbles are produced, obtain a new tube or thoroughly clean the original one.
7. Set one carrot tube and one hydrogen peroxide tube in each of four small beakers. Label the beakers A, B, C, and D. Add crushed ice and tap water to one beaker, hot tap water to a second beaker, and room temperature tap water to the remaining two beakers.
8. Place the hot tap water beaker and one beaker with room temperature tap water on the hot plate. On the graphing calculator display under DATA COLLECTION, select MONITOR INPUT. Heat them until the water temperatures reach 60–65°C and 37–38°C respectively. Move the temperature probe between the two until these temperatures are reached.
9. After the beakers on the hot plate have reached their respective temperatures, take them off the hot plate, and remove the temperature probe. Record the temperatures and labels of the beakers in the data table provided.
10. Place the temperature probe into the ice-water bath beaker. Record the temperature and label in the data table. Place the temperature probe in the second room-temperature beaker. Record the temperature and label in the data table. Let the test tubes sit in the beakers for 5 to 10 minutes. Turn the calculator and CBL System off.
11. Pour each tube of hydrogen peroxide into the carrot-cell slurry tube in the same beaker. Stir each test tube quickly with a glass stirring rod, and start timing. Measure the height of foam, from the top of the liquid mixture to the top of the foam, at one-minute intervals for four minutes or until the foam reaches the top of the test tube. Record your data in the table.

ANALYZE AND CONCLUDE

1. **Interpreting Data** Use your data to construct and label a graph for each of your temperature trials. Plot foam height on the vertical axis and time on the horizontal axis.
2. **Interpreting Data** Construct another graph, plotting foam height at three minutes on the vertical axis and temperature on the horizontal axis.
3. **Comparing and Contrasting** Which of the temperatures appears to be optimum for the catalyzed decomposition of hydrogen peroxide by catalase? How does this temperature compare with body temperature?

APPLY AND ASSESS

1. Peroxide ions are produced in plants and animals as a result of cellular reactions. Given that these peroxides can oxidize and damage cell structures, why is the presence of catalase in cells beneficial?
2. Suggest a way in which the gas in the foam might be tested to verify that it was oxygen.

DATA AND OBSERVATIONS

Beaker Number	Temperature of Reactants	Height of Foam After 1 Minute	Height of Foam After 2 Minutes	Height of Foam After 3 Minutes	Height of Foam After 4 Minutes
A					
B					
C					
D					

Name ______________________

Date ____________ Class ____________

Energy Content of Some Common Foods

Experiment 10
Use with ChemLab 20 pages 722–723

Problem
How much energy is released during the combustion of some common food items?

Objectives
- **Interpret** data to calculate the energy released during combustion of pecans, marshmallows, and a food item of your choice.
- **Compare** the energies obtained from the food items.
- **Infer,** based upon the chemical compositions of the foods and upon the amounts of energy obtained, which types of foods contain the greatest amount of energy.

PREPARATION

Materials
oven mitt
bottle opener with can-piercing end
balance
ring stand
small iron ring
empty, clean soft drink can
matches
beaker tongs
empty, clean can, minus the top and bottom lids, approximately the same diameter as the soft drink can
pecan half
2 small marshmallows
large paper clip
100-mL graduated cylinder
food sample of your choice
CBL System
TI Graphing Calculator with unit-to-unit link cable
temperature probe
CBL AC adapter (optional)

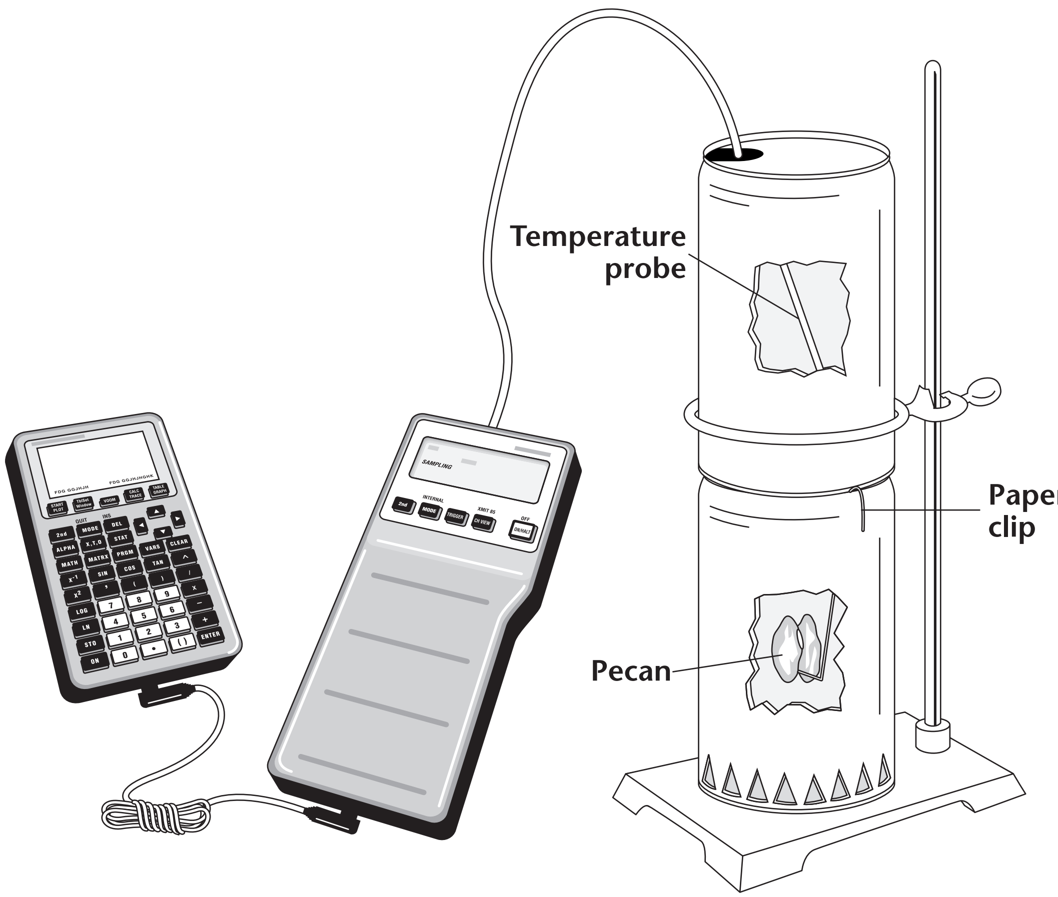
Safety


Wear an apron and goggles. Wear the oven mitt to handle hot items. Be careful in using the match and in handling the cans after each experiment because they may be hot. Perform the experiment in a well-ventilated room because acrid fumes may be produced during the combustion process.

PROCEDURE

1. Plug the temperature probe into Channel 1 of the CBL System. Using the link cable, connect the CBL System and TI Graphing Calculator. Push the link cable securely into each jack.
2. Turn on the CBL System and the graphing calculator. Start the CHEMBIO program and go to the MAIN MENU. If the CHEMBIO program is not loaded, follow instructions with the TI-Graph Link to download the program from your Apple Macintosh or PC computer to your graphing calculator.
3. Select SET UP PROBES from the MAIN MENU. Enter “1” as the number of probes. On the SECLECT PROBES menu select temperature. Enter “1” as the channel number.
4. The MAIN MENU will reappear. Select COLLECT DATA.

Figure 1



5. Use a can opener to open holes near the bottom of the open-ended can. Bend a large paper clip to fashion the food support.
6. Use the graduated cylinder to measure 100 mL of tap water, and pour the water into the soft-drink can. Support this can by the ring stand as shown on this page. Put the temperature probe through the opening in the top of the can. On the graphing calculator display under DATA COLLECTION, select MONITOR INPUT. You can now monitor the temperature on the graphing calculator screen. Allow the probe to reach the temperature of the water. Record the initial water temperature to the nearest 0.1°C in the data table provided.
7. Weigh a pecan half, record its mass, and impale it on the paper-clip food support. Hang the support on the edge of the open-ended can with the food sample inside, and rest the can on the ring stand.
8. Use a match to light the pecan. Quickly swing the water-filled soft-drink can assembly directly over the lower combustion can, allowing a small separation between the two cans.
9. Allow the pecan to burn as completely as possible. If the flame goes out during the process and the pecan is still unburned, you must empty the water in the can and start over with fresh water and a new pecan half. After the pecan has burned out, continue monitoring the temperature until it drops 0.3°C from the highest temperature reached during the experiment. Record the highest temperature.

10. Carefully disassemble the apparatus, empty the water from the soft-drink can, and dispose of the burned food item after it has cooled.
11. Repeat steps 6–10 with two small marshmallows.
12. Repeat steps 6–10 with a small food item of your choice.

ANALYZE AND CONCLUDE

1. **Interpreting Data** Use your data to calculate the number of kilojoules of energy liberated per gram of each food item. Assume that the water in the soft-drink can has a density of 1.00 g/mL and that the specific heat of water is 4.19 J/g°C.
2. **Comparing and Contrasting** Compare and rank the food items according to the amount of energy liberated per gram.
3. **Inferring** Based upon the chemical compositions of the foods you tested (protein, carbohydrate, fat, etc.), what type of food provides the greatest amount of energy per gram?

APPLY AND ASSESS

1. Would it be desirable to eat mainly the type of food that provides the greatest amount of energy per unit mass? Explain.
2. What aspects of your procedure may have caused error in your calculated results? How would each of these sources of error affect your results?

DATA AND OBSERVATIONS

Food Item	Mass (g)	Initial Water Temperature (°C)	Final Water Temperature (°C)
Pecan			
Marshmallow			
Other food			