Greenhouse Effect
Investigating Global Warming

OBJECTIVE
Students will design three different environments, including a control group. They will identify which environment results in the greatest temperature change. Using the temperature probes and the computer graphing software, data will be collected and analyzed for each environment modeled in the experiment. At the end of the experiment, students will be able to define the greenhouse effect and predict future changes in our atmosphere.

LEVEL
Middle Grades: Earth Science

NATIONAL STANDARDS
UPC.2, UPC3, A.1, A.2, B.3, D.2, F.4, F.5

CONNECTIONS TO AP
AP Environmental Science:
   IV. Environmental Quality  A. Air/Water/Soil  1. major pollutants
   V. Global Changes and Their Consequences  A. First-order Effects  1. atmosphere  B. Higher-order Interactions  1. atmosphere

TIME FRAME
50 minutes

MATERIALS
(For a class of 28 working in groups of four)

- 7 LabPros and graphing calculators, LabQuests, or SPARKs
- 850 mL of vinegar
- 21 temperature probes (w/ adaptors if using SPARKs)
- 28 beakers, 600 mL
- 21 rulers
- 21 graduated cylinders, 25mL
- 200 grams baking soda
- 7 lamps with 100 watt bulbs
- several balances
- plastic wrap
- scissors
TEACHER NOTES
The Greenhouse Effect deals with global warming as a result of changes in the composition of the atmosphere. The lab may be done when studying the atmosphere, energy sources or environmental changes.

The students will use the materials provided to create three different environments and measure the changes in temperature for each environment when under a heat lamp for 15 minutes. At the beginning of class, question students regarding their knowledge of Earth’s atmosphere. After brainstorming information, describe the three beakers the students will test during the experiment. The uncovered beaker acts as a control, the covered beaker represents the earth with its atmospheric blanket, and the CO₂ beaker represents an atmosphere with high levels of CO₂. Students will investigate how changing the composition of the atmosphere might change the heat trapping ability of the atmosphere.
### POSSIBLE ANSWERS TO THE CONCLUSION QUESTIONS AND SAMPLE DATA

#### Data Table 1

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Beaker 1</th>
<th>Beaker 2</th>
<th>Beaker 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probe 1 (Celsius) Control Group</td>
<td>Probe 2 (Celsius) W/out Gas Added</td>
<td>Probe 3 (Celsius) W/ Gas Added</td>
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<tr>
<td>0</td>
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ANALYSIS

In the spaces provided in the Data Table 2, subtract to find the temperature differences.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature difference between beaker 1 and beaker 2</th>
<th>Temperature difference between beaker 1 and beaker 3</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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</tbody>
</table>
CONCLUSION QUESTIONS

1. During periods when the lamp was on, did the covered beakers warm faster or slower than the control? Did the covered beakers (beakers 2 and 3) have about the same temperature or different temperatures throughout the experiment?
   - The covered beakers heated faster. The covered beakers were not the same. The beaker with carbon dioxide had a higher temperature.

2. Give a possible explanation for your answers in question one.
   - The covered beakers let heat in, but did not let heat out. Carbon dioxide retains more heat than regular air.

3. What important greenhouse gas did the air in beaker 3 contain?
   - Carbon dioxide

4. During the periods when the lamp was off, did the uncovered beaker cool faster or slower than the covered beakers? Justify your answer.
   - The control beaker (uncovered) cooled off more quickly because it was uncovered and lost heat faster.

5. Explain why a closed automobile heats up in the sun.
   - A closed automobile in the sun allows heat to come into the car but then traps the heat and doesn’t let the heat get out. A closed car acts like a greenhouse when parked in the sun.

6. Explain how a certain level of greenhouse effect is needed.
   - If there was no greenhouse effect the portion of Earth that is experiencing night would have little to no heat. The greenhouse effect keeps us warm at night, without it we would be more like Mercury at night (approximately -168°C). The problem with the greenhouse effect is that it is getting worse as more and more CO₂ (and other gases) is added to our atmosphere.

7. Draw a sketch and describe an experiment to test the ability of methane gas to trap heat.
   - Repeat the experiment as done here, but replace carbon dioxide in the third beaker with methane. Heat with a lamp and measure the change in temperature in the three beakers.
   - The sketch should be accurate based on their procedure, but most likely will look similar to Figure 2.
Greenhouse Effect
Investigating Global Warming

The earth is surrounded by a layer of gases which help to retain heat and act like a greenhouse. Greenhouses allow gardeners to grow plants in cold weather. Radiation from the sun passes through the glass and experiences a change in its wavelength. The new wavelength radiation is unable to pass back through the glass and is trapped inside the greenhouse. As a result the temperature of the air inside the greenhouse is increased. This, along with the lack of mixing between the inside and outside air, keeps the greenhouse consistently warm.

Similarly the gases in our atmosphere trap heat. The main components of our atmosphere are N₂, O₂, CO₂, H₂O and Ar.

![Figure 1](image)

In this experiment you will have three beakers to model different environments. The first beaker will remain uncovered and serve as our control. The second beaker will have a plastic cover, representing the earth with its atmospheric layer. The third beaker will have a plastic cover and additional CO₂ which is a gas that has been increasing in our atmosphere over the last 100 years.

**PURPOSE**
You will analyze temperature data from the three beakers, draw conclusions and make predictions from the data.
MATERIALS
LabPro and graphing calculator, LabQuest, or SPARK  
3 temperature probes (w/ adaptors if using SPARK)  
lamp with 100-watt bulb  
4 beakers, 600 mL  
scissors  

3 rulers  
15 grams of baking soda  
tape  
graduated cylinder  
plastic wrap  
20 mL of vinegar  
balance

Safety Alert
1. Students should avoid touching the heat lamp.
2. Students should wear goggles when mixing the baking soda and vinegar.

PROCEDURE: Data Collection using a LabPro

1. Make a hypothesis about which beaker will retain the most heat. Record your hypothesis on the student answer page.

2. Set up a LabPro with three stainless steel temperature probes, using Channels 1 through 3.

3. To set up the calculator once it is connected to the LabPro:
   a. Press 1. Arrow down to the program EasyData and press [ENTER], the program will automatically detect the three temperature probes.
   b. Select the SETUP tab by pressing [WINDOW] to change the time settings.
   c. Select TIME GRAPH by pressing [2].
   d. Select EDIT by pressing [ZOOM].
   e. Enter the time between samples as [2] and select NEXT by pressing [ZOOM].
   f. Enter the number of samples as [4][5][0] and select NEXT by pressing [ZOOM].
   g. Select OK by pressing [GRAPH].

4. Tape each temperature probe to a ruler as shown in Figure 2. The probe tips should each be 3 cm from the ruler ends and the tape should not cover the probe tips.

5. Obtain four beakers and prepare three of them for data collection, making sure they are clean and dry.

6. Place the temperature probes into the beakers as shown in Figure 2.
7. Cover the top of beakers 2 and 3 tightly with plastic wrap. Remove any excess plastic wrap covering the sides of the beaker. Beaker 1 should be open to air (NO PLASTIC WRAP) and is the control. Beakers 2 and 3 represent your covered greenhouses.

8. In a separate clean beaker, combine 15 grams of baking soda and 20 mL of vinegar. The mixture should immediately produce a gas, as demonstrated in the following equation.

\[
\text{CH}_3\text{COOH (aq)} + \text{NaHCO}_3 (s) \rightarrow \text{NaCH}_3\text{COO (aq)} + \text{H}_2\text{O (l)} + \text{CO}_2 (g)
\]

9. Remove the plastic covering from beaker 3 and pour the gas slowly into the beaker. Be careful and do not allow any liquid to be transferred. After all the gas has been successfully poured into beaker 3, immediately cover it with plastic wrap.

10. Position a light bulb the same distance from all three beakers, about 15 cm above the beakers and the same distance from all three temperature probe tips.

11. Select Start by pressing [ZOOM] to begin data collection. Turn on the lamp. A graph will be displayed as the data is collected.

12. Monitor the time in the meter window. When 5 minutes have passed, turn off the lamp. Data will continue to be collected.

13. At the 10 minute mark, turn the lamp back on. Data collection will stop after 15 minutes.

14. When data collection stops, turn the lamp off and remove the temperature probes from the beakers. A graph will be displayed on the calculator with one line for each temperature probe.

15. Move the cursor to the 0 minute mark on the graph. Determine the temperatures in beakers 1, 2, and 3, and record them in the data table.

16. Use the same method to determine the temperatures for each beaker at the 1 minute (\(x = 60\)), 2 minute (\(x = 120\)), 3 minute (\(x = 180\)), etc. marks and record them in the data table.

17. Complete the Analysis and Conclusion sections for the student answer pages.
PROCEDURE: Data Collection using a LabQuest

1. Make a hypothesis about which beaker will retain the most heat. Record your hypothesis on the student answer page.

2. Set up a LabQuest with three stainless steel temperature probes, using Channels 1 through 3.

3. To set up the LabQuest:
   a. Choose (tap on) the ‘Mode: Time Based’ box from the initial screen.
   b. Change the ‘Timing’ to 1 samples/s. To do so:
      - Tap in the space by ‘Rate,’ a keyboard will pop up
      - Backspace to clear the current numbers and enter 1
      - Tap in the space by ‘Length’
      - Backspace to clear the current numbers and enter 900
      - Choose OK (bottom right on the screen)

4. Tape each temperature probe to a ruler as shown in Figure 2. The probe tips should each be 3 cm from the ruler ends and the tape should not cover the probe tips.

5. Obtain four beakers and prepare three of them for data collection, making sure they are clean and dry.

6. Place the temperature probes into the beakers as shown in Figure 2.

7. Cover the top of beakers 2 and 3 tightly with plastic wrap. Remove any excess plastic wrap covering the sides of the beaker. Beaker 1 should be open to air (NO PLASTIC WRAP) and is the control. Beakers 2 and 3 represent your covered greenhouses.

8. In a separate clean beaker, combine 15 grams of baking soda and 20 mL of vinegar. The mixture should immediately produce a gas, as demonstrated in the following equation.

   \[
   \text{CH}_3\text{COOH (aq)} + \text{NaHCO}_3 (s) \rightarrow \text{NaCH}_3\text{COO (aq)} + \text{H}_2\text{O (l)} + \text{CO}_2 (g)
   \]
9. Remove the plastic covering from beaker 3 and pour the gas **slowly** into the beaker. Be careful and **do not allow any liquid to be transferred**. After all the gas has been successfully poured into beaker 3, immediately cover it with plastic wrap.

10. Position a light bulb the same distance from all three beakers, about 7 cm above the beakers and the same distance from all three temperature probe tips.

11. Begin data collection by pressing the green arrow in the lower left corner of the LabQuest screen. Turn on the lamp. A graph will be displayed as the data is collected.

12. Monitor the time in the meter window. When 5 minutes have passed, **turn off** the lamp. Data will continue to be collected.

13. At the 10 minute mark, **turn the lamp back on**. Data collection will stop after 15 minutes.

14. When data collection stops, turn the lamp off and remove the temperature probes from the beakers. A graph will be displayed on the screen with one line for each temperature probe.

15. Select the “List” tab (the third tab from the left) from the top of the screen and a list of all of the data points will be displayed. Determine the initial temperatures in beakers 1, 2, and 3, and record them in the data table.

16. Scroll down the list and determine the temperatures for each beaker at the 1 minute \((x = 60)\), 2 minute \((x = 120)\), 3 minute \((x = 180)\), etc. marks and record them in the data table.

17. Complete the Analysis and Conclusion sections for the student answer pages.
PROCEDURE: Data Collection using a SPARK

1. Make a hypothesis about which beaker will retain the most heat. Record your hypothesis on the student answer page.

2. Set up a SPARK with three temperature sensors, using the temperature sensor port and two PasPorts with temperature sensors.

3. To set up the SPARK:
   a. Select (by touching) the ‘Build’ icon in the lower right corner of the initial screen.
   b. Build a page consisting of a table with columns for each sensor. To do so:
      - Select ‘Temperature1’
      - Select the table button
      - Select OK from the bottom right corner
   c. Add columns for sensors 2 and 3. To do so:
      - Select the table button and a menu will appear on the right side of the screen
      - Select the add column button twice and the table will have 4 columns
      - Assign sensor 2 to the third column: select the display properties button, then select the appropriate boxes so that Column 3 has a measurement of Temperature\(_2\) in \(^\circ\text{C}\), select OK
      - Assign sensor 3 to the fourth column: select the display properties button, then select the appropriate boxes so that Column 4 has a measurement of Temperature\(_3\) in \(^\circ\text{C}\), select OK
      - Select the table button to close the right-hand menu
   d. Change the data collection parameters. To do so:
      - Select the sampling options button at the bottom of the screen
      - For the ‘Sample Rate’ select ‘1’
      - For the ‘Sample Rate Unit’ select ‘Hertz’
      - Select OK
      - The Spark will display ‘Periodic: 1 Hertz’ and is ready to collect data

4. Tape each temperature sensor to a ruler as shown in Figure 2. The sensor tips should each be 3 cm from the ruler ends and the tape should not cover the sensor tips.

5. Obtain four beakers and prepare three of them for data collection, making sure they are clean and dry.
6. Place the temperature sensor(s) into the beakers as shown in Figure 2.

![Figure 2](image)

7. Cover the top of beakers 2 and 3 tightly with plastic wrap. Remove any excess plastic wrap covering the sides of the beaker. Beaker 1 should be open to air (NO PLASTIC WRAP) and is the control. Beakers 2 and 3 represent your covered greenhouses.

8. In a separate clean beaker, combine 15 grams of baking soda and 20 mL of vinegar. The mixture should immediately produce a gas, as demonstrated in the following equation.

\[
\text{CH}_3\text{COOH} (aq) + \text{NaHCO}_3 (s) \rightarrow \text{NaCH}_3\text{COO} (aq) + \text{H}_2\text{O} (l) + \text{CO}_2 (g)
\]

9. Remove the plastic covering from beaker 3 and pour the gas slowly into the beaker. Be careful and do not allow any liquid to be transferred. After all the gas has been successfully poured into beaker 3, immediately cover it with plastic wrap.

10. Position a light bulb the same distance from all three beakers, about 15 cm above the beakers and the same distance from all three temperature sensor tips.

11. Begin data collection by pressing the green arrow in the lower left corner of the SPARK screen. Turn on the lamp.

12. Monitor the time in the meter window. When 5 minutes have passed, turn off the lamp. Data will continue to be collected.

13. At the 10 minute mark, turn the lamp back on. Data collection will stop after 15 minutes.

14. After 15 minutes have passed, stop the data collection by pressing the red arrow in the lower left corner. Turn the lamp off and remove the temperature sensors from the beakers.

15. Use the data table to determine the initial temperatures in beakers 1, 2, and 3, and record them in the data table.

16. Scroll down the list and determine the temperatures for each beaker at the 1 minute (x = 60), 2 minute (x = 120), 3 minute (x = 180), etc. marks and record them in the data table.

17. Complete the Analysis and Conclusion sections for the student answer pages.
HYPOTHESIS

DATA AND OBSERVATIONS

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Beaker 1</th>
<th>Beaker 2</th>
<th>Beaker 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probe 1 (Celsius) Control Group</td>
<td>Probe 2 (Celsius) W/out Gas Added</td>
<td>Probe 3 (Celsius) W/ Gas Added</td>
</tr>
<tr>
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</table>
ANALYSIS
In the spaces provided in the Data Table 2, subtract to find the temperature differences.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Temperature Difference Between Beaker 1 and Beaker 2 (Celsius)</th>
<th>Temperature Difference Between Beaker 1 and Beaker 3 (Celsius)</th>
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</table>
CONCLUSION QUESTIONS

1. During periods when the lamp was on, did the covered beakers warm faster or slower than the control? Did the covered beakers (beakers 2 and 3) have about the same temperature or different temperatures throughout the experiment?

2. Give a possible explanation for your answers in question one.

3. What important greenhouse gas did the air in beaker 3 contain?

4. During the periods when the lamp was off, did the uncovered beaker cool faster or slower than the covered beakers? Justify your answer.

5. Explain why a closed automobile heats up in the sun.

6. Explain how a certain level of greenhouse effect is needed.

7. Draw a sketch and describe an experiment to test the ability of methane gas to trap heat.