The GREENHOUSE EFFECT a good thing?

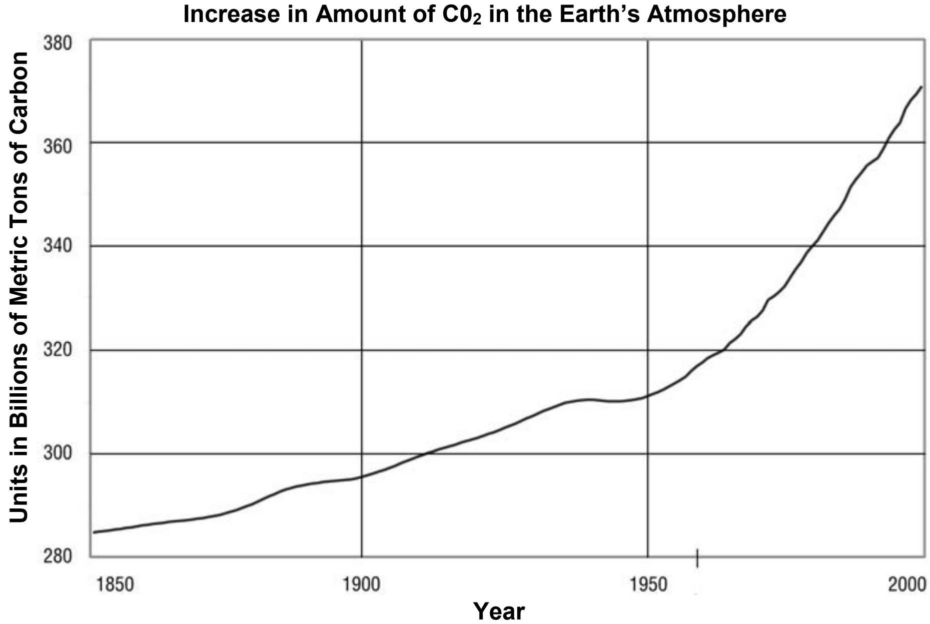
ACTIVITY

Focus Question
Can increased greenhouse gases in our atmosphere change the temperature at the surface of the Earth?

Activity Overview

Certain gases in the Earth's atmosphere such as carbon dioxide (CO_2) and water vapor, known as the greenhouse gases, trap energy from the sun. This is known as the greenhouse effect. The greenhouse effect is necessary to keep the Earth warm enough for life. However, levels of CO_2 in our atmosphere have been increasing dramatically and scientists speculate that this could be causing global warming.

Increase in Amount of $C0_2$ in the Earth's Atmosphere



In this activity you will model the greenhouse effect using bottles sealed with plastic wrap and the air you exhale, which is high in CO_2 and water vapor. You will simulate the sun with a lamp, and collect temperature data with Temperature Sensors that are connected to a TI CBL2™ or Vernier LabPro and a TI-73 Explorer™. You will collect and analyze temperature data in two conditions: a sealed bottle and a sealed bottle into which you breathe.

What factors might affect the temperature in the bottles? What conclusions can you make about the effects of increasing amounts of greenhouse gases in the atmosphere?

The GREENHOUSE EFFECT

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Procedure

1 Prepare the Temperature Sensors.

a. Label two Temperature Sensors (1, 2)

2 Connect Temperature Sensors to the CBL2™ or LabPro (interface) and the interface to the TI-73 Explorer™.

a. Plug Temperature Sensor 1 into channel 1 of the CBL2™ or LabPro.
b. Plug Temperature Sensor 2 into channel 2 of the CBL2™ or LabPro.
c. Use the link cable to connect the TI-73 Explorer™ to the interface.
d. Firmly press in the cable ends.

3 Set up the TI-73 Explorer™.

a. Turn on the TI-73 Explorer™ and start DATAMATE. *(For instructions on DATAMATE, see Appendix A.)*
b. Press [CLEAR] to reset the program.
c. Select SETUP from the MAIN SCREEN.
d. If the TI-73 displays a temperature sensor in each channel [CH 1: TEMP (C), CH 2: TEMP (C)] then **skip to Step 4**. If not, continue with this step to set up the sensors manually.
   - Press [ENTER] to select CH1.
   - Select TEMPERATURE from the SELECT SENSOR MENU.
   - Select the correct Temperature Sensor (in °C) from the TEMPERATURE MENU.
   - To select CH 2, press [▼] once, then press [ENTER].
   - Select TEMPERATURE from the SELECT SENSOR MENU.
   - Select the correct Temperature Sensor (in °C) from the TEMPERATURE MENU.

4 Set up the TI-73 Explorer™ for data collection.

a. Use [▲] and [▼] to select MODE and press [ENTER].
b. Select TIME GRAPH from the SELECT MODE MENU.
c. Select CHANGE TIME SETTINGS from the GRAPH SETTINGS MENU.
d. Enter "15" as the time between samples in seconds. Press [ENTER].
e. Enter "60" as the number of samples. Data will be collected for 15 minutes (900 seconds). Press [ENTER].
f. Select OK to return to the SETUP SCREEN.
g. Select OK again to return to the MAIN SCREEN.

5 Prepare the heat source.

a. Place the two bottles next to each other on the table about 2 cm apart. Mark the position of the bottles using tape.
b. Center the lamp above the bottles about 10 cm away.

6 Prepare the bottles and add carbon dioxide and water vapor.

a. Label two bottles (1, 2). Make sure the bottles are completely dry with no water droplets remaining inside or outside.
b. Cut two 10 cm x 10 cm squares of plastic wrap.
c. Using a sharp pencil, poke a small hole in the center of each square of plastic wrap.

ACTIVITY

Materials*

- TI-73 Explorer™
- TI CBL2™ or Vernier LabPro
- TI-73 DataMate
- 2 Temperature Sensors
- Lamp with 100-watt bulb
- 2 Clear 1 L bottles
- 2 Rubber bands
- Black construction paper
- Masking tape
- Plastic wrap
- 1 Pencil

TI-73 Explorer™

* This activity has been written for the TI-73 Explorer™ but you can easily substitute the TI-83 or TI-83 Plus. Also see Appendix A for steps on how to transfer DataMate to your graphing device and how to use DataMate for data collection.

Adapted from "Experiment 24 — The Greenhouse Effect," *Earth Science with Calculators,* written by Johnson, Robyn L. , DeMoss, Gretchen Stahmer, and Sorensen, Richard, published by **Vernier Software & Technology**, 2002.

d. Flood Bottle 1 with carbon dioxide and water vapor. To do this, inhale, hold your breath as long as possible, and then exhale slowly into the bottle. Repeat this several times.
e. Place a square of plastic wrap over each bottle opening making sure to position the small hole over the center. Secure the plastic wrap tightly to the bottle using rubber bands.
f. Breathe a few more times into the small hole of Bottle 1. Lay the bottles on their side on the marked position on the table.
g. Gently slide Temperature Sensor 1 through the hole into Bottle 1 and Temperature Sensor 2 into Bottle 2.
h. Use a small piece of masking tape to make sure the sensors are in the middle of the bottle and not resting on the sides.
i. To prevent direct heating of the sensors, wrap the areas of the bottles that contain the sensors with black construction paper.

7 Collect your temperature data.

a. Select START on the TI-73 Explorer™.
b. Turn the light on.
c. Your graphing device will collect data for 15 minutes and will stop automatically. The TI-73 Explorer™ displays the temperature inside Bottles 1 and 2 on the upper right of the screen. The device generates a real-time graph of both bottles.
d. Turn the light off and remove the Temperature Sensors from the bottles.

8 Analyze your data.

a. At the end of the 15 minutes, a graph will be displayed for the two sensors (one for each channel).
b. Use the data collected and your devices to complete the Data Analysis section. Answer the questions in your journal.

↺ *To do the experiment again, press* [ENTER] *to return to the MAIN SCREEN.*

TI-73 Explorer™

CBL2™

Temperature Sensor

Adapted from "Experiment 24 — The Greenhouse Effect," *Earth Science with Calculators,* written by Johnson, Robyn L. , DeMoss, Gretchen Stahmer, and Sorensen, Richard, published by **Vernier Software & Technology,** 2002.

Data Analysis

1. Use a ✓ to identify the factors that relate to each bottle in Table 1. (Copy the table in your journal.)

Table 1

Factors	Bottle 1	Bottle 2
Sealed with Plastic Wrap		
Heat Source		
Added Carbon Dioxide		
Added Water Vapor		

2. Draw a sketch of the graph created by your graphing device.

*Move the cursor along each curve to answer questions 3-5 and record your answers in the table provided. Use the left and right arrow keys (◂, ▸) to move the cursor along a curve. Use the up and down arrow keys (▴,▾) to move the cursor from one curve to the next. The **time (x)** and **temperature (y)** values of each data point are displayed below the graph.* Note: The matching Sensor number for each curve is displayed in the upper right corner of the screen.

3. What is the temperature of each bottle at 5 minutes (x = 300)? Record your temperatures in Table 2. (Copy the table in your journal.)

4. What is the temperature of each bottle at 10 minutes (x = 600)? Record your temperatures in Table 2.

5. Record the time interval (change in time) in seconds between the 5-minute mark and the 10-minute mark in Table 2.

6. Record the change in temperature for each bottle between the 5-minute mark and the 10-minute mark in Table 2.
Hint: Change in Temperature = Column 2 − Column 1

Table 2

Elapsed Time	5 Minutes Temp (°C) (1)	10 Minutes Temp (°C) (2)	Change in Temp (°C) (2-1)	Change in Time (seconds)
Bottle 1				
Bottle 2				

7. During the entire 15-minute time period (900 seconds), is the temperature inside each bottle increasing or decreasing?

8. The steepness of a line on your graph indicates how fast the temperature is changing. For example, a steep line indicates that the temperature is changing quickly. A line that is almost flat indicates that the temperature is changing slowly.

   According to your graph, which bottle had the fastest increase in temperature between the 5-minute mark and the 10-minute mark? *Hint: Which line is the steepest?*

9. Which bottle had the slowest increase in temperature during the same time period?

10. Another method to find how fast the temperature is changing within the specified time interval is to find the slope of each line on your graph. The **slope of a line** is defined as the rate of change between two points on a graph. The slope formula will give a numerical value to compare how fast the temperature is changing in each bottle. The greater the slope, the faster the change in temperature. Using the formula for slope (see below) and the values you recorded in Table 2, find the slope of the lines representing the temperatures inside each bottle between the 5-minute mark and the 10-minute mark. Show your work and record your answers in Table 3. (Copy the table in your journal.) *Note: Use seconds for change in time.*

$$\text{Slope} = \frac{\text{Change in Temperature}}{\text{Change in Time}}$$

Table 3

	Slope
Bottle 1	
Bottle 2	

11. According to your calculations, which bottle had the fastest increase in temperature between the 5-minute mark and the 10-minute mark? *Hint: Which line had the greatest slope?*

12. Which bottle had the slowest increase in temperature during the same time period?

13. In questions 10, 11, and 12 you used two data-points to find the slope and used the slope to compare the temperature changes inside each bottle. DataMate can also be used to make the same comparisons by looking at all the data points within the 5-minute time interval. Follow the steps below to determine how fast the temperature is changing inside each bottle. The letter A on your display will represent how fast the temperature changed. Record the value of *A* for each bottle in Table 4. (Copy the table in your journal.)

Find the rate of change between the 5-minute mark and the 10-minute mark on the graph for each bottle using DataMate.

1. **Select the Time Interval.**
   a. Press ENTER to return to the MAIN MENU.
   b. Select GRAPH and press ENTER.
   c. Select SELECT REGION.
   d. Using the right arrow key ▸, move the cursor to the 5-minute mark (x = 300), and press ENTER.
   e. Using the right arrow key ▸, move the cursor to the 10-minute mark (x = 600), and press ENTER.

2. **Calculate the rate of change for Bottle 1.**
   a. Press ENTER again and select MAIN SCREEN to return to the MAIN MENU.
   b. From the MAIN MENU, select ANALYZE.
   c. From the ANALYZE OPTIONS MENU, select CURVE FIT.
   d. From the CURVE FIT MENU, select LINEAR (CH 1 VS TIME).

3. **Calculate the rate of change for Bottle 2.**
   a. Press ENTER twice to return to the ANALYZE OPTIONS MENU.
   b. From the ANALYZE OPTIONS MENU, select CURVE FIT.
   c. From the CURVE FIT MENU, select LINEAR (CH 2 VS TIME).

Table 4

	(A) **5-minute Interval**
Bottle 1	
Bottle 2	

14. According to your DataMate calculations, which bottle had the greatest change in temperature during the 5-minute interval?

15. Which bottle had the least change in temperature during the 5-minute interval?

16. Based on your data and your data analysis, what factor(s) had an effect on how fast temperature changed? *Hint: You may refer to Tables 1, 2, 3, and 4.*

17. Which bottle had the highest temperature at the end of 15 minutes?

18. How much higher was the temperature than the other bottle?

19. Based on your data and your data analysis, and the information about greenhouse gases from the JASON XV Research Article, describe how the increase of carbon dioxide in the atmosphere may be responsible for changes in our planet's climate.

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