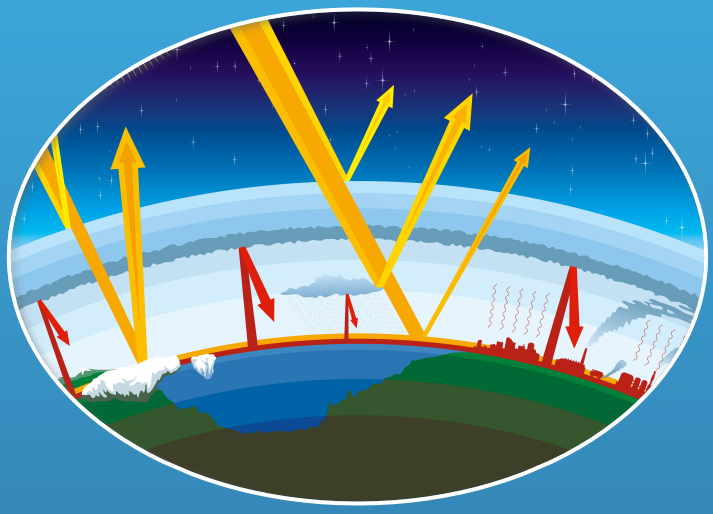

Global Warming and the Greenhouse Effect: A laboratory exercise

A laboratory exercise prepared by Beyond Benign as part of the Green Chemistry in Higher Education program: A workshop for EPA Region 2 Colleges and Universities

Global Warming and the Greenhouse Effect:
A laboratory exercise

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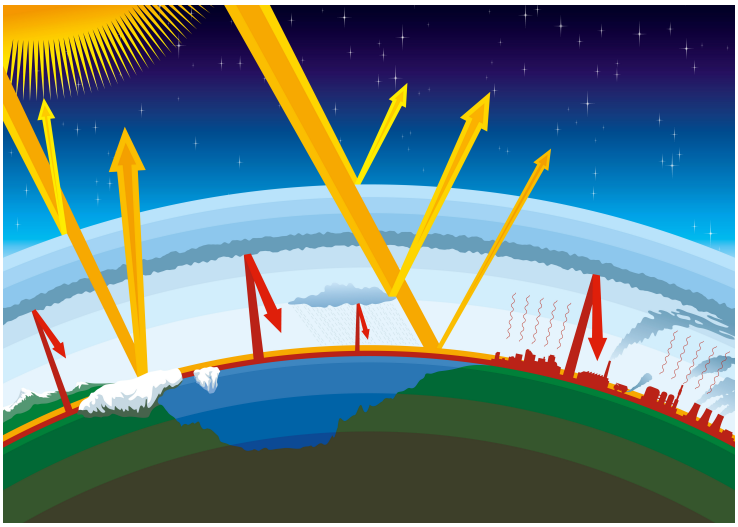


The Global Warming and Greenhouse Effect laboratory exercise was developed as a result of a workshop held at Siena College in 2013, which was funded by a EPA Region 2 Source Reduction grant[1] titled *Green Chemistry in Higher Education: A Workshop for Region 2 Colleges and Universities*. The Green Chemistry in Higher Education workshop was carried out at Siena College on July 18-21, 2013. 29 faculty members participated from 20 different institutions in New York and New Jersey. The workshop consisted of three main focus areas: green chemistry case studies for lecture and course work, green chemistry laboratory exercises, and toxicology and environmental impact.

The Global Warming and Greenhouse Effect laboratory exercise was developed to demonstrate global warming for introductory chemistry courses for both majors and non-majors. The laboratory experiment has been implemented at two universities: Alfred University and Monmouth University. The experiment is presented in the following pages; along with instructor background information, preparation information and student hand-out sheets.

[1] **Disclaimer: Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement X9-96296312 to Beyond Benign, it has not gone through the Agency's publications review process and, therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred.**

Instructor Background and Preparation Information

Global Warming and the Greenhouse Effect

Summary:

The earth is naturally warmed through a process called the greenhouse effect. Greenhouse gases absorb thermal radiation in the atmosphere to produce a natural warming of the earth. Scientists have found that the addition of anthropogenic sources of greenhouse gases is resulting in the warming of the earth, the transitioning of climates, the deglaciation of continents, and rising sea levels. This laboratory demonstrates how greenhouse gases, such as carbon dioxide, can contribute to Global Warming and Climate Change.

Objectives:

- To understand the affects of greenhouse gases on the environment
- To understand the concept of the greenhouse effect
- To understand climate change chemistry
- To understand how green chemistry can help to create solutions to the global challenges

Chemistry Concepts:

Thermodynamics, Green House Effect, Equilibrium, Properties of Gases

Purpose: To demonstrate the impact of greenhouse gases, such as carbon dioxide, on the warming of the earth.

Time required: 60 minutes

Materials:

- 2 Tupperware containers with clear top (recommended container: Rubbermaid Lock-Its, 9 cup size, 8.5 x 8.5 x 3 inches)
- 2 digital thermometers with temperature probes (recommended: Pyrex Digital Probe Thermometer, or Taylor 1470 Digital Cooking Thermometer/Timer)
- 2 grow light bulbs with clamp or lamp stand (recommended: 60W grow light with clamp-on light fixture)
- 2 ring stands to secure the light fixtures
- small beaker (50 – 150 mL)
- small amount of dry ice and gloves/tongs to pick it up with
- black construction paper
- scissors
- ruler
- timer or stopwatch

Advanced preparation:

Students can assemble the "greenhouses" themselves, or you can prepare the set-ups for them and they can run the experiment. You can use the Tupperware containers as-is and place the temperature probes in to the containers. However, please note that the cord to the temperature probe will have to fit snugly under the cover of the container and might allow for leakage of the carbon dioxide. To avoid this, a small hole can be drilled in to the Tupperware and the probe can be inserted in to the container, then sealed with silicone in order to create a good seal.

Other advanced preparation can include: Cutting out the black construction paper to fit on the bottom of the Tupperware, the size must be kept consistent. Measuring how far away the lamp is from the top of the Tupperware and how far the Tupperware is from the edge of the table, both of these must be kept consistent for both environments. Obtaining dry ice from a cold temperature room or icebox.

Carbon dioxide preparation: place a 5 gram (small piece) of dry ice in 30 ml of warm water and use a glove when handling dry ice.

Safety information: wear goggles, handle the dry ice with glove/tongs it can cause skin burns. All other lab safety procedures should be followed.

Taking it further:

- compare the greenhouse effect and global warming
- how does the earth benefit from the greenhouse effect
- test other gases against the atmospheric gas
- identify consumer products that generate greenhouse gases; propose alternatives to these products that could eliminate the generation of greenhouse gases

Student Handout

Global Warming and the Greenhouse Effect

Summary:

The earth is naturally warmed through a process called the greenhouse effect. Greenhouse gases absorb thermal radiation in the atmosphere to produce a natural warming of the earth. Scientists have found that the addition of anthropogenic sources of greenhouse gases are resulting in the warming of the earth, the transitioning of climates, the deglaciation of continents, and rising sea levels. This laboratory demonstrates how greenhouse gases, such as carbon dioxide, can contribute to Global Warming and Climate Change.

Objectives:

- To understand the affects of greenhouse gases on the environment
- To understand the concept of the greenhouse effect
- To understand climate change chemistry
- To understand that green chemistry can help to create solutions to the global challenges

Materials:

- 2 Tupperware containers
- 2 digital thermometers with temperature probes
- 2 lamps with light bulbs
- small beaker (50 – 150 mL)
- small amount of dry ice and gloves/tongs to pick it up with
- black construction paper
- scissors
- ruler
- timer or stopwatch

Procedure:

- Cut out two equal size pieces of black construction paper to fit the bottom of the Tupperware containers
- Place about 5g of dry ice (a small cube) in 30 mL of warm water in the small beaker
- Place the beaker in one of the Tupperware containers so that it fills with CO_2
- Allow the Tupperware container to fill up with dry ice (about 60-90 seconds)
- Insert a temperature probe into the Tupperware container containing CO_2
- Remove the beaker from the container and seal the cover onto the container to seal in the CO_2 (do this quickly)
- Place the second temperature probe in to the Tupperware container containing atmospheric air and then seal the cover on to the container (this will be your control).
- Place the containers side by side beneath the lights
- Measure the distance from the tops of each of the containers to their respective lights and be sure that the distance is the same

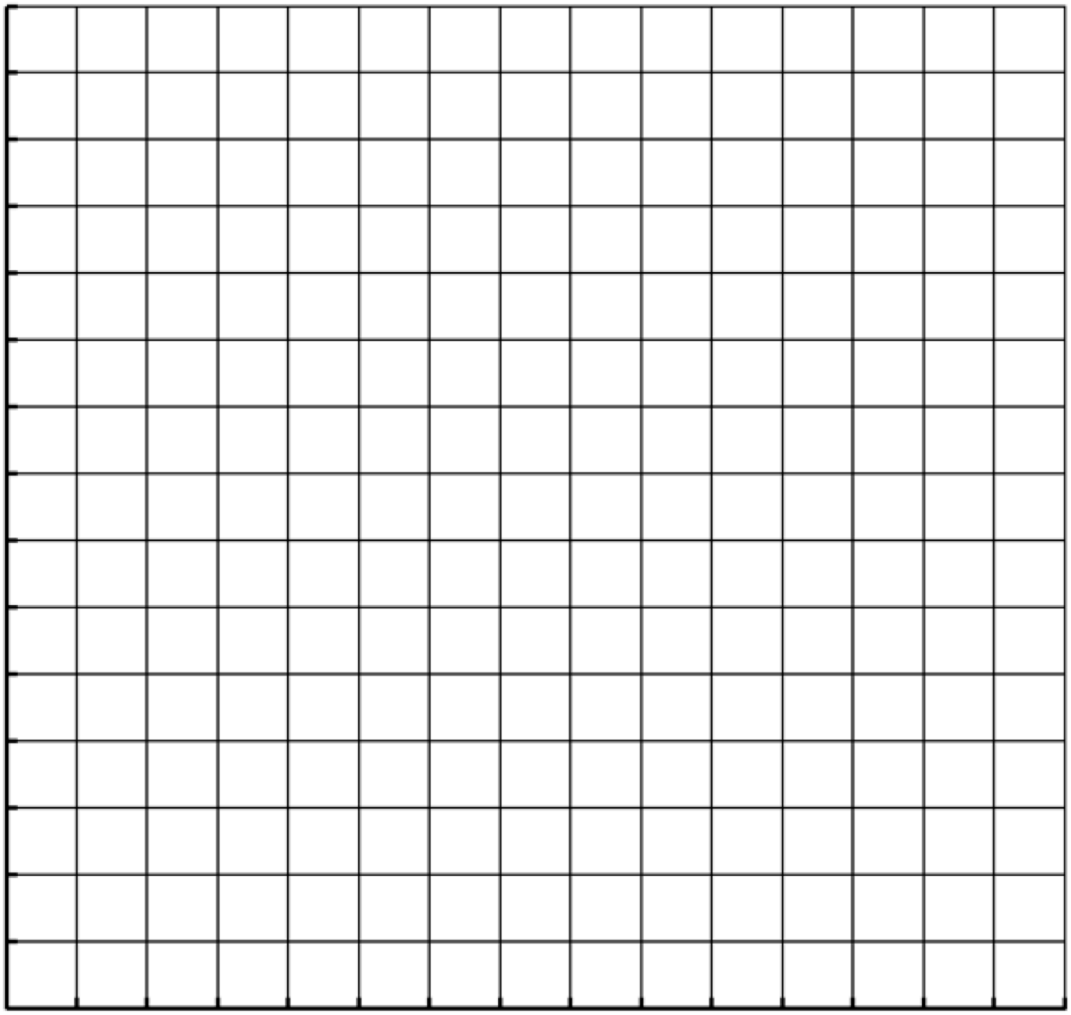
- Measure how far away the Tupperware container is from the edge of the table, and make sure that both are equal.
- Wait until the temperatures within the containers have equilibrated to the same temperature. Once the temperatures have equilibrated, simultaneously turn on lights and record start time
- Record the temperature every 2 minutes following turning on the lights for 15 – 20 minutes.

Time (minutes)	Atmospheric air Temperature (˚F)	Carbon dioxide Temperature (˚F)
0 minutes		
2 minutes		
4 minutes		
6 minutes		
8 minutes		
10 minutes		
12 minutes		
14 minutes		
16 minutes		
18 minutes		
20 minutes		

Questions:

1. What was the overall temperature change for the atmospheric air only container? The carbon dioxide container? Which was greater? Why?

2. Plot the data from your table (both groups) above in the line graph provided below. Be sure to label your axes and provide an appropriate scale as well as a title. Also be sure to include a key to differentiate the groups of data.



Concluding questions:

1. The CO_2 in the second container represents the layer of greenhouse gases that surround the Earth, explain why the CO_2 in this experiment as well as that which surrounds the Earth is able to trap heat.

2. Evaluate and enumerate the pros and cons of the greenhouse effect. Is it all bad? Describe two ways in which people can practically mitigate their daily output of greenhouse gases.

3. In what ways could you improve on the procedure of this experiment to more accurately model the real world greenhouse effect? List at least two improvements that could be made.

4. How can green chemistry contribute to finding solutions to Global Climate Change and Global Warming?

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http://www.greenchemistrycommitment.org/resources/case-studies/