BOTTLING UP GREENHOUSE GASES INQUIRY

(Developed by Jim Hartman)

Introduction

Greenhouse gases (GHGs) have molecules that can absorb Infra-Red (IR) radiation and re-radiate them so that they and their energy does not escape out into space. Greenhouse gases can be natural or human caused. All warm objects give off IR Radiation. The chart below shows the different variables your teacher may allow you to use and possible sources.

GHG Source	Specific GHG Gases	Collection Details & Material Needs
Your exhalation	CO_2 and water vapor	First exercise then use straw
Car exhaust	CO_2 and Nitrous oxide	Capture with file folder/duct tape funnel
Wood smoke	CO_2 and particulates	Light a paper twist and extinguish in bottle
Water vapor	water	Lightly use a sprayer so there is no puddling
Dust off electronics spray	HCFC	Briefly spray (Research what specific gases you have)
Natural gas	Methane	Use your classroom burners or a camp stove
Stinky wetland muck	Methane & Nitrous oxide	Your control can be fresh dirt and water
Active compost	CO_2	Your control can be bad soil and water

Concepts

Greenhouse effect Greenhouse gases Reproducible Experiment

Background

You will be given an outline of a procedure. It is up to you to fill in the details so another person could reproduce your results. As you can see on the diagram on the separate handout, you will take two identical bottles and tape a black strip in each so they will heat up and give off IR Radiation. Duct tape will be used on the mouth of the bottle to seal in the GHGs. A hole will be made to place a thermometer inside so you can measure how it heats up over time (Start the hole with a nail and enlarge with a pen). The key to doing good science is to be very specific and use numbers to describe your bottles, black strip and how often you measured the temperature. You will heat up both bottles equally, using a heat lamp inside or the sun itself if weather permits. Why do you have two bottles?

Like many scientists, you are going to be making a model to describe a complex situation. Climate change is complex since the earth is complex. For example, consider that the atmosphere has many layers and greenhouse gases last for different amounts of time. Scientific models provide useful information but are imperfect. Model airplanes can help one make a real airplane. As you do this inquiry, think about how your model is imperfect, yet useful. Always think about how you can improve your experiment, as every scientist does.

Essential Materials for each pair of students:

2 good thermometers (make sure the line is unbroken)

2 identical glass bottles stopwatch

duct tape to seal bottles black paper scissors Nail

Clamp Lamp with Aluminum Shield fitted with 100 Watt light bulb →

Experimental Tips

When measuring temperature, just keep the stopwatch running. If you are taking a measurement near 2 minutes, you can keep an eye on both thermometers and get readings from 1 min. 50 sec. to 2 min. 10 sec.

Make sure your two chambers are equidistant from your light source.

Be very gentle with the thermometers. Be careful that your bottle does not fall over which can break the thermometers.

Safety precautions & special considerations

- If you are working with natural gas, make sure there are no hot electric coils around which could ignite your methane (It can be explosive if you have a mixture of that is 5% to 17% natural gas).
- If you are collecting car exhaust, do not touch the hot tail pipe and try to avoid breathing the exhaust. The exhaust can be funneled into a trash bag and later added to your bottle. Also note that a car that has just started up produces the most amount of nitrous oxide.
- If you are burning paper with matches, do not throw matches and paper in the trash can after the paper has been extinguished. Use an empty can instead, preferably with some water inside.
- If you are working with wetland muck or active compost, allow one or two days for the gas to develop once the chamber is sealed.

Answer these questions before you do the experiment:

1. Why do you have two bottles?

2. What is your hypothesis: Which bottle do you think will heat up fastest and why?

3. Procedure Questions:

    a. Why should you label both bottles?

    b. What do you do if at room temperature, one thermometer reads 20 ^{o}C, and the other 21^{o}C?

    c. Looking at your thermometer, how accurate should you measure temperature, to the nearest ^{o}C or half ^{o}C? Why?

d. How can you make sure you only have one variable? Be specific and list at least 3 details. Hint: If your variable was smoke, how did you ensure that at the start each of your bottles had the same temperature?

i.

ii.

iii.

Do this part as you set up and conduct your experiment:

e. Write your step by step procedure on a separate sheet of paper and attach to this packet (Be super detailed so someone else could reproduce your experiment). Note that when you collect data, 10 to 20 minutes should be sufficient.

After you have collected your data:

f. Rewrite your data table neatly below. Be sure to include units like minutes and °C.

g. Transform your data to highlight patterns: <u>Do one of the following:</u>

i. Do a percent difference calculation. For example, if the control went up 3 °C and the experimental chamber went up 4 °C, the experimental temperature difference went up 33% more than the control. Here's the math: ((4-3)/3 * 100 = 33%).

ii. Graph your data on a full page sheet of graph paper and attach it to this packet. Consider graphing temperature difference or temperature. Which would be best? Be sure to spread out the data by using appropriate scales. Don't forget to label each axis and include units. Place your independent variable on the Y axis. This is the variable data that is independent and may surprise you.

4. What patterns do you see in your data? Find at least two. For example, you may consider which bottle heated up the fastest at first or what happened to the rate of heating at the end of your data collection.

First Pattern: ____

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Proposed Explanation: ____

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Second Pattern: ____

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Proposed Explanation: ____

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5. List at least two specific errors you made in your experiment.

First error:

Second error:

6. If you were going to build on this experiment, what related experiment would you do next?

TEACHER TIPS

This lab is an open ended one and designed to give students ownership of the process. You do not necessarily have to get all the materials. If a student wants to do stinky wetland muck as a methane source, then they can find a way to gather it and bring to school.

The two patterns the data should show are:

1. The Chamber with the greenhouse gas will heat up more, usually in less than 10 minutes.
2. Both chambers will heat up fastest at first. As the chambers get warmer they will start to radiate more heat and not increase in temperature as much.

Demonstration: You may also decide to model the lab by doing a chamber with a black strip and one without. Here is what the data may look like:

Time (minutes)	0	2	4	6	8
Control Temp (°C)	26.0	30.5	31.5	33.0	34.0
Black Strip Temp (°C)	25.0	31.0	33.5	35.0	36.0

Have students do some of the other variables after the teacher demonstration. Later students could present their findings to the class.

One key to getting good data is to create a wide temperature spread. A 100 Watt incandescent lamp which is 12 inches from each bottle can do the trick. If the bottles start out relatively cool and are brought out to a hot sunny day that also helps.

Extensions:

A. Once you have measured the warming of both chambers, you can remove the heat source and measure the cooling.
B. What happens if you a plastic chamber instead of glass?
C. Consider other variables: Size of mason jar, color of paper strip, angle of light source, black paper strips vs. aluminum foil painted black.
D. If you have the Vernier probes, you can measure the CO_2 levels in the two chambers as part of the experiment. This equipment costs at least $269 per probe.

In terms of time required to do the lab, there are different ways to set this up. If you limit it to simple variables like exhalation and water vapor, it could be done in one period. If you have 90 minute periods, this lab could take up 3 of them:

Day 1:

Possible special Prep: Teacher has brought in a cup each of stinky wetland muck in a sealed container, active moist compost and dirt (bad soil). If you need chambers to ferment or respire, you may want to skip a class period (Insert some other content or activity so that the greenhouse gases have time to be created.

Lecture/discussion on inquiry: How is your life affected by science? How is inquiry related to science. How can the inquiry process help reduce climate change?

Fill out chart of Greenhouse gases (In appendix)

Go over lab and introduce sealed bottle and diagram. Ask students what will happen to it when placed in the sun. If possible, go outside in the sun and take a few readings.

Have student pairs sign up for variables (It's ok for two or three pairs to do the same variable).

Have students collect and label containers as well as cut up black strips.

Day 2:

Teacher goes over experiment reminders.

Students gather data, start write up of experiment.

Day 3:

Students finish inquiry write up.

Lab groups briefly present their findings (5 minutes each). Share data transformation on document camera.

Alignment to NGSS (2013):

Disciplinary Core Ideas: Middle School

MS-ESS3 Earth and Human Activity ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change

Disciplinary Core Ideas: High School

HS-ESS3 Earth and Human Activity ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change

Science and Engineering Practices: Developing and using models Planning and carrying out investigations

Crosscutting Concepts: Systems and system models Energy and matter Stability and change