

GREENHOUSE GASES: THE CLIMATE CHANGE CULPRIT

GRADES 7-12

MATERIALS

2 clear, empty 2-liter bottles
2 thermometers (digital is ideal, but any 6-inch thermometer that can be suspended can be used)
String to suspend thermometers in bottles
2 Alka-Seltzer tablets or similar store-brand antacid product
Bottle lids, clay, or rubber stoppers-needed to make a closed system
Heat lamp*
Attached worksheet

*In order to complete the experiment in one class period, a heat lamp is recommended. Alternatively, a halogen work light could be used, but the experiment may take more time for temperature differences to be observed.

DEFINITIONS

Atmosphere-The envelope of gases surrounding the earth or another planet

Emission-The release of a gas or other substance into the air

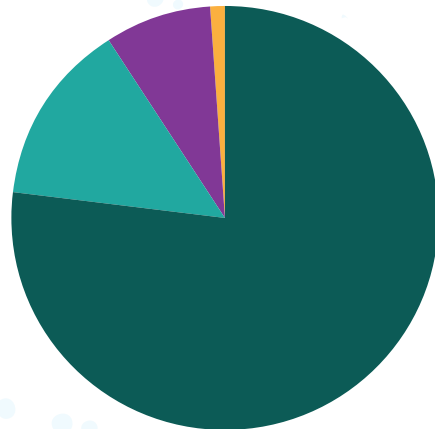
Fluorinated gas-A group of artificially produced, fluorine-containing greenhouse gases that can stay in the atmosphere for hundreds to thousands of years; their main uses are for refrigerants, fire extinguishers, and foam products

Gas-An airlike fluid substance which expands freely to fill any space available, irrespective of its quantity

BACKGROUND

The root of climate change is in our warming planet. According to the EPA, the average air temperature for Earth has risen 1.4°F in the past 100 years. Many people hear that and think it's not much of a problem, forgetting that averages are determined by adding highs and lows and dividing those over many years. That means that temperatures are both higher and lower than average in different locations around the globe.

% OF GREENHOUSE GASES



CO₂ = 77%

Methane = 14%

Nitrous Oxide = 8%

Fluorinated Gases = 1%

Intergovernmental Panel on Climate Change (IPCC), 2007

Temperature is crucial to life on earth. Climate change is believed to have been the cause of the extinction of the dinosaurs. Many species of plants and animals are able to adapt to small changes in climate over long periods of time. However, temperatures are expected to continue to rise at an increased rate, possibly increasing by 11.5°F over the next 100 years. According to Robert Henson, author of *Rough Guide to Climate Change*, the 21st century was the hottest on record, and could possibly be the hottest in the last millenium. This is happening within our lifetimes. Warmer temperatures impact nearly every aspect of life on Earth. Oceans become more acidic, the polar ice caps melt and cause sea level rise, and air pollution increases. Plants and animals that cannot adapt die out.

Greenhouse gases are necessary for life on earth. The sun's rays are absorbed and heat the earth. When the earth cools, it gives off infrared radiation. Greenhouse gases prevent some of this radiation from reflecting back into space. This is the greenhouse effect. Excess greenhouse gases trap excess radiation, warming the planet even more.

Some greenhouse gases, like water vapor and CO₂, occur naturally in the atmosphere. However, human activities, especially those associated with industrialization, have rapidly increased atmospheric CO₂ and other greenhouse gases. Greenhouse gases called fluorocarbons are emitted only by human activities.

The predominant greenhouse gases (excepting water vapor) in our atmosphere are pictured in the pie graph. Carbon dioxide is the most common greenhouse gas emitted, yet it is not the most potent. Both methane and nitrous oxide have more Global Warming Potential, or GWP, respectively, and are more potent than CO₂.

The GWP is an estimation of the potential of greenhouse gases to warm the atmosphere for a certain period of time, usually 100 years. GWP calculations are determined by three main factors-the ability of the gas to absorb infrared radiation, what radiation wavelengths the gas absorbs, and the average length of time the gas remains in the atmosphere. Carbon dioxide, as the reference gas, has a GWP of 1. These calculations are periodically updated by the Intergovernmental Panel on Climate Change. The current 100-year GWP for methane is 21, and for nitrous oxide 310.

While just 1% of total greenhouse gas emissions, fluorinated gases are the most potent of all because they last so long in the atmosphere. It is difficult for scientists to determine how long CO₂ remains in the atmosphere, because a number of different processes remove it from the air. However, it is estimated that most CO₂ not stored in carbon sinks (the ocean and forests) can last in the atmosphere 20-200 years, possibly several thousand. Methane lasts 12 years, nitrous oxide lasts 114, but fluorinated gases can last 270-50,000 years.

Refrigerants used in air conditioners, refrigerators and freezers are a major source of fluorinated gases. Some of these fluorinated gases are being phased out under an international agreement called the Montreal Protocol because they deplete the ozone layer, which serves as a shield, preventing the sun's harmful ultraviolet B radiation from penetrating the atmosphere. However, hydrofluorocarbons, HFCs, developed to replace ozone-depleting fluorinated gases, are also potent greenhouse gases.

Because they remain in the atmosphere for such a long time, fluorinated gases continue to affect our climate long after human activity has stopped emitting them into the atmosphere. GWPs for fluorinated gases can range from 1300 to 11700.

TEACHER PREPARATION

Watch the following demonstration at

<http://www.youtube.com/watch?v=kwtt51gvaJQ>. This demonstration took over an hour, but if it is modified as suggested below, can be done in 30-45 minutes.

INSTRUCTIONS

1. Fill both bottles approximately $\frac{1}{3}$ of the way with tap water.
2. Suspend a thermometer in the first bottle, making sure that the suspended thermometer does not touch the water. Cap tightly, attach clay, etc. to make closed system, or cap with rubber stopper and insert probe of digital thermometer.
3. Break 2 Alka-Seltzer tablets and drop in second bottle. Attach thermometer in the same way as the first bottle.
4. Turn on heat lamp. The bottles should be about 6 inches away from the heat lamp.
5. Check the temperature in each bottle in 25-30 minutes. You should see a higher temperature in the bottle with CO₂ released from the Alka-Seltzer tablets.
6. During the wait, students can work on the table portion of the attached Greenhouse Gas Worksheet.

Optional:

If there is time, students can visit the EPA's carbon footprint calculator (<http://www.epa.gov/climatechange/ghgemissions/ind-calculator.html>) or the Cool Climate Carbon Footprint Calculator (<http://coolclimate.berkeley.edu/carboncalculator>) to see how much carbon dioxide they or their family contributes.

ADDITIONAL RESOURCES

For Teachers:

<http://www.youtube.com/watch?v=ZzCA60WnoMk> (NASA video on greenhouse effect and climate change)

http://earthguide.ucsd.edu/virtualmuseum/climatechange1/02_1.shtml (Provides a simple comprehensive guide to climate change and greenhouse gases with illustrations)

http://www.epa.gov/climatechange/Downloads/wycd/Climate_Basics.pdf (EPA's guide to basic climate change information)

<http://www.astc.org/c3/GreenhouseGasActivities.pdf> (Additional CO₂ science experiments that are easy to do in the classroom)

<http://ncse.com/climate> (National Center for Science Education - Initiative for Climate Change website with rationale, support and resources for teaching climate change)

GREENHOUSE GAS WORKSHEET

Name _____

Name the four most abundant greenhouse gases.

What effect do greenhouse gases have in the atmosphere?

Greenhouse Gases (ranked) <i>1 = most abundant</i> <i>4 = least abundant</i>	Years Present in Atmosphere	Human Source	Natural Source	Chemical Formula	Ways to Reduce or Stop Emissions
1.					
2.					
3.					
4.					

Experimental Results

Starting Time _____

Bottle 1 (just water) Starting Temperature _____

Bottle 2 (water plus antacid tablet) Starting Temperature _____

Ending Time _____

Bottle 1 (just water) Ending Temperature _____

Bottle 2 (water plus antacid tablet) Ending Temperature _____

Temperature Change in Bottle 1 (Ending Temperature - Starting Temperature) = _____

Temperature Change in Bottle 2 (Ending Temperature - Starting Temperature) = _____

What temperature difference was observed between the two bottles? What factor(s) can explain this temperature difference?