Can Gases Act Like a Greenhouse?
Adapted from www.planetconnecticut.org

Students conduct a controlled experiment to confirm whether a gas -- in this case, carbon dioxide (CO_2) -- can act like a greenhouse. In the experiment, students contrast the temperature rise in a CO_2 rich atmosphere to that of normal air when both environments are exposed to a bright light. Through this, students can infer a potential for increasing levels of atmospheric carbon dioxide leading to global warming.

Objectives

Students will carry out a scientific inquiry of the greenhouse effect that involves collecting, charting, and interpreting temperature data. In devising their interpretation of data, students will need to describe air as a mixture of gases, apply the law of conservation of energy, identify energy transformations (including radiant to heat and heat to radiant), compare and contrast sunlight to infrared radiation, and identify evidence that light, such as sunlight, can transfer energy between two points.

Time

One to two class periods depending on how much of the lab set-up is done before hand and the length of the pre-lab and follow-up discussions.

Materials

.. Two empty plastic 2-liter soda bottles
.. Ruler
.. Two thermometers
.. One 150-watt spotlight
.. Light stand
.. A clock or watch
.. Four cups of dark, dry soil
.. Two straws - or - rubber tubing
.. One small plastic container and piece of modeling clay - or - glass flask with a rubber 1-hole stopper
.. Three alka-seltzer tablets
.. Water
.. Data Log handout

Pre Lab Set-Up

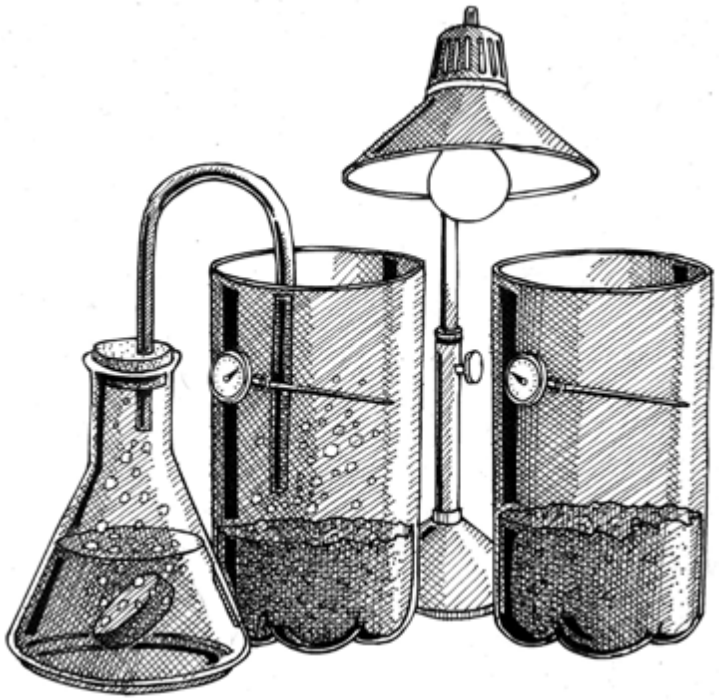
1. Cut off the tops of the empty two-liter bottles to make two open-mouthed bottles eight inches in height. Punch a small hole in each bottle 5 inches up from the bottom.

2. Place 2 inches of dry, dark soil in the bottoms of each plastic bottle. Insert a thermometer through the holes in the bottles so that their ends are in the middle of the air space.

3. Position the light 8 to 10 inches from the top of the bottles and equal distance from both.

4. Build a tall arched tube out of two straws by inserting the end of one into the end of the other. Insert one end of the tube in the top of the small bottle and secure with modeling clay. Position the container with lid and tube so that the other end of the tube is held one inch above the soil in one of the 2-liter bottles. Use tape or other means as needed to hold the tube in place. (If using a glass flask, rubber stopper, and rubber hose, connect the hose to the hole in the stopper and position the other end of the tube one inch above the soil in one of the 2-liter bottles.)

5. Fill the small plastic container (or glass flask) halfway with water.



Background Information

When sunlight strikes the earth's ground, water, and biomass they all absorb radiation and heat up. Some of this heat is conducted to the air next to the earth and some is re-radiated as infrared radiation.

In a greenhouse, the heat that is conducted to the air is trapped within the greenhouse walls and so builds up in the relatively small space of the greenhouse. This is one "greenhouse effect". But it is not the "greenhouse effect" that is warming our planet.

If the greenhouse is made up of glass, a second "greenhouse effect" comes into play as well. Glass is transparent to sunlight, but is effectively opaque to infrared radiation. Therefore, the glass warms up when it absorbs some of the infrared radiation that is radiated by the ground, water, and biomass. The glass will then re-radiate this heat as infrared radiation, some to the outside and some back into the greenhouse. The energy radiated back into the greenhouse causes the inside of the greenhouse to heat up.

If the greenhouse is covered with polyethylene instead of glass, this second effect doesn't come into play because polyethylene is effectively transparent to infrared radiation. Yet polyethylene-covered greenhouses work almost as well as glass ones. This indicates that the primary way that greenhouses heat up is by restricting the flow of warmed air to the outside of the greenhouse.

Greenhouse Gases

Greenhouse gases trap heat in the same way that glass does. Greenhouse gases warm up when they absorb some of the infrared radiation that is radiated by the ground, water, and biomass. These gases will then re-radiate this heat as infrared radiation, some out into space and some back toward the earth.

Running the Experiment

1. Check to make sure that:
    a. One end of the tube or straw is inserted into the container holding water so that one end is positioned at least one inch from the water and the other end is held one inch above the soil in one of the 2-liter bottles.
    b. The lamp is positioned 8 to 10 inches from the top of the bottles and equal distance from both.
    c. Each bottle has a thermometer inserted through a hole in its side so that the end of the thermometer is in the middle of the air space.

2. Place one alka-seltzer tablet in the container of water, seal top with modeling clay (or stopper), and wait 90 seconds. Repeat with second and third tablet. Remember to wait 90 seconds after inserting each tablet.

3. One 2-liter bottle should now be filled with carbon dioxide (CO_2). (CO_2 is heavier than air, so it will stay in the container.)

Remove the straw from the bottle so that no more CO_2 can enter.

4. Turn on the light. Observe and record the temperature in each bottle every minute for 10 minutes on the data log. (The CO_2 will dissipate in about ten minutes through convection currents set up by the warming environment.)

5. Plot the results on a graph and discuss your results.

Can Gases Act Like a Greenhouse?

Name(s) _____

_____

_____

_____

Date _____

Time (minutes)	**Temperature of CO_2-rich atmosphere (units _____)**	**Temperature of normal atmosphere (units _____)**
0		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		