Can Gases Act Like a Greenhouse?

Activity 1

Following a discussion that enables student to express what they already know about the greenhouse effect, 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 identifying preconceived ideas, developing questions, and the collection, charting, and interpretation of 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.

Standards

Students will develop basic explanations for natural phenomena, and the ability to ask good questions and apply experimental procedures to collect and analyze data. Students will address standards 5.1, 6.1, 6.3, 9.1, 9.5, scientific inquiry, scientific literacy, and scientific numeracy from Connecticut's Core Science Curriculum Framework.

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. The homework assignment will require one to several days depending on how readily students have access to the Internet and whether the teacher requires research on the Internet.

Materials

For discussion

- newsprint

Per Lab Setup

- Two empty plastic 2-liter soda bottles
- Ruler
- Two bitherm 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 with lid (such as an empty cheese-dip container) - or - glass flask with a rubber 1-hole stopper
- Three alka-seltzer tablets
- Water
- Data Log handout

Preparation

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 bitherm 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. Punch a small, straw-sized hole in the top of the container lid. (Skip this step if using a glass flask with rubber 1-hole stopper.)

5. 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 hole in the container lid. 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.)

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

Homework Preparation

Review the homework assignment and the reading for Activity 2, *Carbon Is (almost) Everywhere*. Decide on how you want students to present their work and decide on which of the homework criteria described in the assignment students must meet. (Older grades, or those familiar with chemical formulas, should complete more of the criteria.)

Method

Extension Activity

During the weeks prior to starting this unit, suggest to students that they bring in news articles and website information on the greenhouse effect, global warming, and global climate change to post on a bulletin board.

Pre Lab Discussion

Divide the students into groups of four. Have the groups take eight minutes to write a list of what they think they know about the greenhouse effect. Suggest that each group start by taking three minutes for individuals to write their own ideas, then share ideas as a group.

As a class, list what the students think they know about the greenhouse effect on pieces of newsprint that can be referred to later. Ask each group in-turn to contribute an idea.

Continue until all ideas are recorded. It is all right for a group to pass if all of their ideas are already recorded.

In groups, have students take five more minutes for each student to write down one question they have about the greenhouse effect that no one else in their group can answer.

Have students post their questions next to the newsprint. Ask the class if anyone can suggest an answer to any of the questions.

Tell the class that you will leave the ideas and questions for students to refer to as they gather and evaluate information about the greenhouse effect. Explain that the class will begin their investigations by conducting an experiment on a simple model of the Earth's atmosphere.

Lab Activity

Hand out the student worksheets and have students work in pairs to run the experiment.

Follow-up Discussion

All students will have experienced a greenhouse effect at different times in their lives. Perhaps some have experienced an actual greenhouse. Most will have experienced the heat built up in a closed car on a sunny day. Ask students to come up with some examples of when they have experienced a greenhouse effect in their lives. Ask them to devise a hypothesis or explanation to make sense of the evidence they experienced. (You may want to have the students conduct a second experiment using the same two 2-litter bottles only this time covering one bottle securely with plastic wrap. This experiment will have to progress over a longer period of time to clearly see a greenhouse effect.)

Ask them to also come up with a hypothesis or explanation to make sense of the evidence they experienced in the preceding greenhouse gas experiment. In each case, have students address how the energy from the light (radiation) moves into and out of the system and changes form. Tell them they can check their ideas against information on the following web sites.

Two sites that provide animated explanations of the earth's greenhouse effect:

www.planetguide.net/book/chapter_3/greenhouse_effect.html

www.epa.gov/globalwarming/kids/global_warming_version2.html

In class, review with the students the information covered in the following section (Background Information). You may want to ask students to role-play a plastic covered greenhouse, a glass-covered greenhouse, and greenhouse gases. Have the students play the roles of sunlight, a heated object, infrared radiation, hot air, a glass covering, a plastic covering, and greenhouse gases.

Be sure to emphasize that our planet's greenhouse effect is a good thing. It keeps our planet at a livable temperature. Concerns over global warming and global climate change

come from an increasing level of this "good thing". This will be covered more in the next two lessons on the carbon cycle and climate change.

Homework

Handout the homework assignment *The Carbon Cycle* and the reading from Activity 2, *Carbon Is (almost) Everywhere!*.

Tell students which of the criteria described in the assignment they must meet. (Older grades, or those familiar with chemical formulas, should complete more of the criteria.) Describe to students how you want them to present their story of the carbon atom. This may be as a collage, a written report, a graphical representation, or some other idea of your own.

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

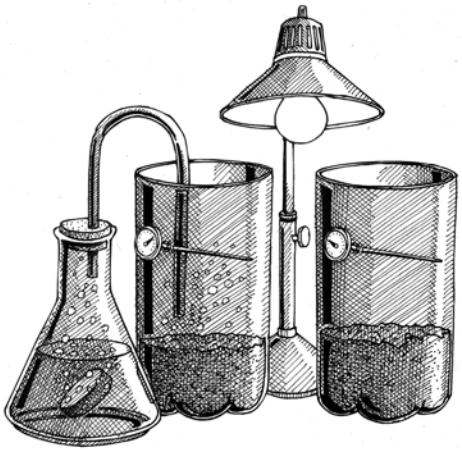
In a greenhouse, the heat that is conducted to the air is trapped within the greenhouse walls and so builds up in the relatively small space of the greenhouse. This is one "greenhouse effect". But it is not the "greenhouse effect" that is warming our planet.

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.



Can a Gas Act as a Greenhouse?

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 bitherm thermometer inserted through a hole in its side so that the end of the thermometer is in the middle of the air space.

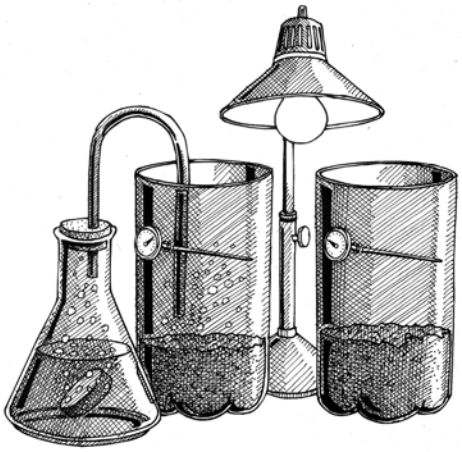
2. Place one alka-seltzer tablet in the container of water, close the lid (or stopper), and wait 90 seconds. Repeat with second and third tablet. Remember to wait 90 seconds after inserting each tablet.

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.



Date _____

Name(s) _____

_____

_____

Data Log

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		

Homework Assignment – The Carbon Cycle

I. **Research Assignment**: For information to help you with this assignment, read
   1) the handout *Carbon Is (almost) Everywhere*,
   2) the animation found on the web site www.epa.gov/globalwarming/kids/carbon_cycle_version2.html
   3) resources you find by entering the term "carbon cycle" into a search engine such as Google.

II. **Compose a story** of an imaginary carbon atom as it moves through Earth's ecosystems. Your teacher will describe how your story is to be presented. Your story must meet the following criteria:

   1) Your carbon atom must complete a cycle. In other words, it must end in a location similar to where it started.

   2) Your carbon atom must spend time at least once in each of the following locations:
      - The atmosphere
      - A living thing
      - The ocean
      - In a fossil fuel such as oil or coal

   3) Each time your carbon atom moves, describe what happens to make it move.

   4) For each location your carbon atom goes to, identify whether your carbon atom is part of a gaseous, liquid, or solid molecule.

   For higher grades:

   For each location your carbon atom goes:

   5) Identify one or more element(s) that a carbon atom would typically bond with to form a molecule.

   6) Describe the chemical composition of a typical molecule containing carbon