Heat Absorption by Gases

Ed Farrar

Topic

Global warming

Time

2 to 3 hours

Safety

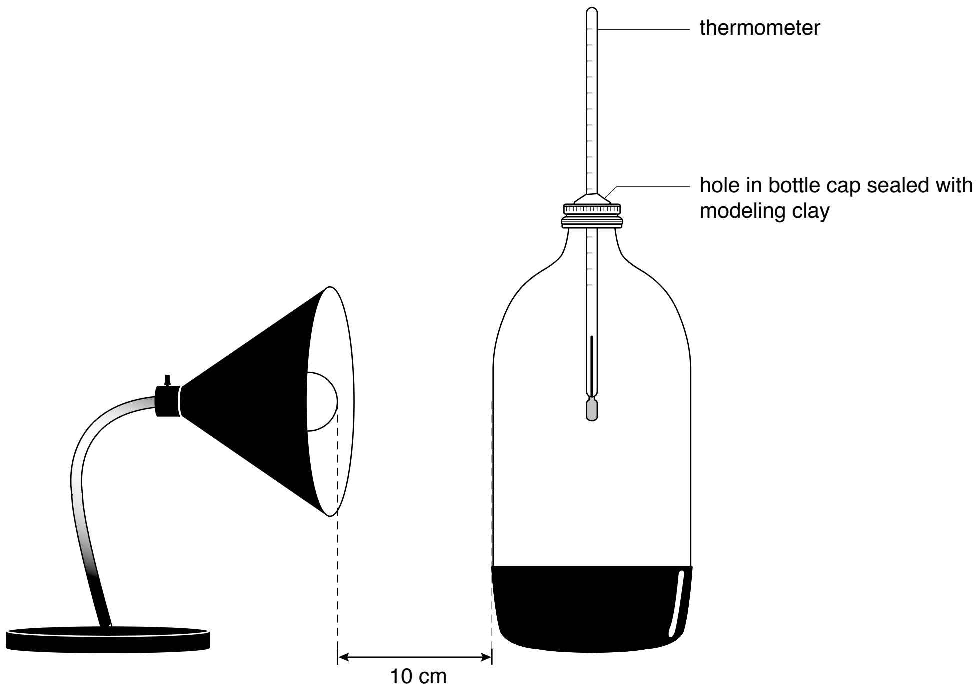
Please click on the safety icon to view the safety precautions.

Materials

two 2-L soft-drink bottles
digital watch
light source (reading light, 100 watts or greater)
masking tape
marker
thermometer (must have graduations in degrees centigrade marked on its body)
hammer
large nail
ruler
1 tbs dry ice (frozen CO_2 [carbon dioxide])
modeling clay

Procedure

1. Set up the equipment as shown in the illustration. Using the hammer and nail, make a hole in the cap of one of the bottles just large enough so that the thermometer will fit through it. You can close any gaps around the thermometer with modeling clay if necessary.
2. Put a piece of tape down on a tabletop and mark off 10 cm. Place the edge of the lamp or bulb and the side of one of the bottles on the lines 10 cm apart. Place the dry ice in the second bottle, and set this aside to change to a gas (CO_2), leaving the cap off the bottle. Because CO_2 is denser than air, it will stay in the bottle.
3. Record the starting temperature of the first bottle. Turn on the light, and record on the data table the temperature every 2 min for 30 min.
4. Make sure that there is no dry ice remaining in the second bottle. Remove the cap and thermometer from the bottle of air, and place them in the bottle filled with CO_2.
5. Allow the CO_2 to come to room temperature, and repeat step 3.



6. Make a temperature vs. time graph of your data. Put temperature (in degrees centigrade) on the vertical axis and time (in minutes) on the horizontal axis. Plot data points for the two gases in two different colors, then draw lines through the points to show the pattern of temperature rise for each gas.
7. Which gas became the hottest? Subtract the starting temperature of each gas from its temperature at 30 min. How many degrees did each temperature rise?
8. If you were told that the amount of carbon dioxide is increasing in our atmosphere, what might you guess would be the effect on the temperature of our world?

DATA TABLE

Time (min)	Temperature (°C)		Time (min)	Temperature (°C)	
	Air	CO_2		Air	CO_2
0			16		
2			18		
4			20		
6			22		
8			24		
10			26		
12			28		
14			30		

What's Going On

Your graph should show two distinct lines, with the line representing CO_2 rising more steeply than the line representing air. Results will vary depending on the specific conditions under which you ran the experiment: room temperature, the type of light used, etc. Generally the carbon dioxide should rise in temperature about 1° to 2°C more than the air. This is because of the structure of the CO_2 molecule and the fact that as it absorbs heat it vibrates, creating an even higher temperature. The earth's atmosphere is made up mainly of oxygen and nitrogen, along with a much smaller percentage of argon, carbon dioxide, and water vapor. The water vapor and the carbon dioxide in the earth's atmosphere are the "greenhouse gases" that absorb heat and maintain the earth's temperatures. Carbon dioxide will absorb, and give off, more heat than the air, so an increase of carbon dioxide in the atmosphere would tend to cause greater absorption of heat and lead to rising temperatures.

The recent trend known as *global warming* is probably due partly to an increase in the CO_2 component in the earth's atmosphere. Other gases such as methane, that are not naturally occurring atmospheric components, also are considered factors in global warming. One potential danger of this warming trend is rising temperatures at the poles and melting portions of the polar ice caps, which could cause flooding of coastal areas. In this experiment, you compared the heat absorption of air (made up mainly of nitrogen and oxygen, with smaller amounts of argon, carbon dioxide, and water vapor) with that of carbon dioxide (CO_2).

Connections

The gases in the earth's atmosphere allow heat from the sun to reach the planet and warm its surface. The earth's surface radiates some of this heat back into the atmosphere where it is absorbed and reemitted, maintaining the earth's temperatures and climates. This process is called the *greenhouse effect,* and it is the reason why the earth can sustain life. Over past centuries, the impact of human life—especially industry—has increased the amounts of certain gases in the atmosphere. The question is: How do these changes affect temperature trends on earth? Chlorofluorocarbons (freons) are a class of chemical compounds that have an impact on the earth's ozone layer. CFCs are prevalent in refrigerants, solvents, and aerosol propellants. From 1970 to 1979, two satellites gathered information indicating that the ozone layer was decreasing approximately .5% per year, or 3% from 1978 to 1984. The decrease of the ozone layer has a direct affect on the increase of skin cancer rates.

Safety Precautions

READ AND COPY BEFORE STARTING ANY EXPERIMENT

Experimental science can be dangerous. Events can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. Basic safety procedures help prevent serious accidents. Be sure to follow additional safety precautions and adult supervision requirements for each experiment. If you are working in a lab or in the field, do not work alone.

This book assumes that you will read the safety precautions that follow, as well as those at the start of each experiment you perform, and that you will *remember* them. These precautions will not always be repeated in the instructions for the procedures. It is up to you to use good judgment and pay attention when performing potentially dangerous procedures. Just because the book does not always say "be careful with hot liquids" or "don't cut yourself with the knife" does not mean that you should be careless when simmering water or stripping an electrical wire. It *does* mean that when you see a special note to be careful, it is extremely important that you pay attention to it. If you ever have a question about whether a procedure or material is dangerous, stop to find out for sure that it is safe before continuing the experiment. To avoid accidents, always pay close attention to your work, take your time, and practice the general safety procedures listed below.

PREPARE

- Clear all surfaces before beginning work.
- Read through the whole experiment before you start.
- Identify hazardous procedures and anticipate dangers.

PROTECT YOURSELF

- Follow all directions step by step; do only one procedure at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure that there is adequate ventilation.
- Do not horseplay.
- Wear an apron and goggles.
- Do not wear contact lenses, open shoes, and loose clothing; do not wear your hair loose.
- Keep floor and work space neat, clean, and dry.
- Clean up spills immediately.
- Never eat, drink, or smoke in the laboratory or near the work space.
- Do not taste any substances tested unless expressly permitted to do so by a science teacher in charge.

USE EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives and other sharp or pointed instruments with caution; always cut away from yourself and others.
- Pull plugs, not cords, when inserting and removing electrical plugs.
- Don't use your mouth to pipette; use a suction bulb.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Clean up broken glassware immediately.

- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use only low-voltage and low-current materials.
- Be careful when using stepstools, chairs, and ladders.

USING CHEMICALS

- Never taste or inhale chemicals.
- Label all bottles and apparatus containing chemicals.
- Read all labels carefully.
- Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING INSTRUCTIONS

- Use goggles, apron, and gloves when boiling liquids.
- Keep your face away from test tubes and beakers.
- Never leave heating apparatus unattended.
- Use safety tongs and heat-resistant mittens.
- Turn off hot plates, bunsen burners, and gas when you are done.
- Keep flammable substances away from heat.
- Have a fire extinguisher on hand.

WORKING WITH MICROORGANISMS

- Assume that all microorganisms are infectious; handle them with care.
- Sterilize all equipment being used to handle microorganisms.

GOING ON FIELD TRIPS

- Do not go on a field trip by yourself.
- Tell a responsible adult where you are going, and maintain that route.
- Know the area and its potential hazards, such as poisonous plants, deep water, and rapids.
- Dress for terrain and weather conditions (prepare for exposure to sun as well as to cold).
- Bring along a first-aid kit.
- Do not drink water or eat plants found in the wild.
- Use the buddy system; do not experiment outdoors alone.

FINISHING UP

- Thoroughly clean your work area and glassware.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Don't dispose of materials in the sink unless instructed to do so.
- Wash your hands thoroughly.
- Clean up all residue, and containerize it for proper disposal.
- Dispose of all chemicals according to local, state, and federal laws.

BE SAFETY-CONSCIOUS AT ALL TIMES