GREENHOUSE GASES AND GLOBAL WARMING

Prep Time: 30 minutes
Teaching Time: 3 hours 30 minutes

INSTRUCTIONS
Grade 10

Science Teacher Education Program

Science Concept:

Energy can change forms and be transferred.

Objectives:

The student will:

- design and conduct an experiment to test the effect of greenhouse gases on heat transfer;
- collect and record data and write a prediction and conclusion to an experiment; and
- graph and analyze data.

GLEs Addressed:

Science

[10] SA1.1 The student demonstrates an understanding of the process of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[10] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred, and conserved by examining energy (i.e., nuclear, electromagnetic, chemical, mechanical, thermal) transfers and transformations by comparing usefully energy to total energy.

Math

[10] S&P-1 The student demonstrates an ability to classify and organize data by designing, collecting, organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers, community, or careers), using information from tables or graphs that display two or more sets of data or with technology.

Vocabulary:

solar radiation - energy that comes from the sun in the form of electromagnetic radiation, mostly at wavelengths of between 1.0 and 0.1 micrometers

terrestrial radiation - longwave electromagnetic radiation that is emitted by Earth back into the atmosphere, in contrast to the shortwave radiation that is emitted by the sun

greenhouse gas - a gas that contributes to the greenhouse effect by absorbing infrared radiation

radiometer - an instrument for detecting or measuring the intensity or force of radiation

Materials:

- Safety goggles (one per student)
- Plastic bottles (two per group)
- Carbon dioxide source*
- Thermometers or temperature probes (two per group)
- Timer (one per group)
- Radiometers (one per group)
- Lamp and bulb or sunlight (one per group)
- Paper (black and white)
- Cans (one black and one white)

* Carbon dioxide can be obtained by the sublimation of dry ice or through the reaction of baking soda and vinegar. It is heavier than air and can be poured from a beaker. If using dry ice, do not keep the solid in a sealed container because carbon dioxide expands when it changes form from a solid to a gas.

Activity Procedure:

Please refer to the assessment task and scoring rubric located at the end of these instructions. Discuss the assessment descriptors with the class before teaching this lesson.

Gear Up

Process Skills: observing and inferring

1. Divide the class into groups of two to three. Distribute a radiometer and lamp to each group. Ask students to turn on the lamp, place the radiometer under the lamp and observe for one or two minutes. Ask each group to describe their observations and inferences to the rest of the class.

Explore

Process Skills: predicting, observing, and inferring

2. Explain that groups will investigate the transfer of energy and heat absorption using thermometers, colored paper, and a source of radiant energy, such as a light bulb or sunlight. Distribute a sheet of black and a sheet of white paper and two thermometers to each group. Instruct groups to place a thermometer under each sheet of paper and record the temperature at 5-minute intervals for 30 minutes.

Generalize

Process Skills: communicating and predicting

3. As a class, discuss the following questions:
   a. Which color paper had the highest temperature?
   b. Explain the difference in temperature between the white and black papers.
   c. How does energy transfer from light to non-visible objects? (i.e., gases in atmosphere)
   d. Do you think some gases absorb more energy than others?
   e. What gases are present in the atmosphere?
   f. Does carbon dioxide absorb more solar radiation than air?

Experiment

Process Skills: predicting, observing, measuring, collecting data, making graphs, inferring, experimenting, and communicating

4. Instruct groups to form a hypothesis as to whether carbon dioxide will absorb more energy than air, design an experiment to test the hypothesis, and write a procedure for the experiment. Groups should list all materials needed to conduct the experiment. Discuss safety concerns with the class, and check each group's procedure before allowing them to procede. Groups should collect data in a table and make a graph of the temperature change over time.
5. The following is an example procedure:
   a. Put a thermometer in each of two plastic bottles. (NOTE: If using a temperature probe, poke a hole in each of the caps large enough for the temperature probe to fit through. Insert probe through hole so it hangs in the center of the bottle and seal hole with clay so it is airtight.)
   b. Fill one of the bottles with carbon dioxide. Put caps on both bottles. Position a lamp the same distance from both bottles so it shines equally on each. Record data at 5-minute intervals for 30 minutes.

Interpret

Process Skills: communicating and interpreting data

6. Ask each group to discuss which bottle absorbed more energy and why.
7. Ask each group to share its hypothesis and data with the class.

Apply

Process Skills: communicating, measuring, collecting data, making graphs, inferring, experimenting, and communicating

8. Ask students to write a conclusion to their experiment that explains how the experiment relates to global warming and describes the transfer of energy from solar radiation to terrestrial radiation. Ask students to compare the carbon dioxide concentration in the bottle to the carbon dioxide concentrations in Earth's atmosphere. Discuss as a class.

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RUBRIC

Assessment Task

Design another experiment using greenhouse gases. Try different gases, different concentrations or different wavelengths of light. Observe and record the effects on temperature. Graph results and include labels on the graph. (NOTE: Be careful; some gases are not safe to heat.)

Rubric

Objective	GLE	Below Proficient	Proficient	Above Proficient
The student collects and records data, and writes a prediction and conclusion to an experiment.	[10] SA1.1	Some data is missing.	Data is collected and recorded in a data table. The student's prediction is stated and a conclusion is written.	Data is collected and recorded in a data table. The student's prediction is stated and an accurate conclusion is written.
The student designs and conducts an experiment to test the effect of greenhouse gases on heat transfer.	[10] SB2.1	The student's experiment does not demonstrate a transfer in energy.	The student's experiment demonstrates a transfer in energy, and the student explains how the energy is transferred.	The student's experiment demonstrates a transfer in energy, and the student explains how the energy is transferred. The student designs and describes an extension experiment.
The student graphs and analyzes data.	[10] S&P-1	One or more parts of the student's graph (title, labels, data, scale) are missing or inaccurate.	One part of the student's graph (title, labels, data, scale) is missing or inaccurate. The student uses the data to explain the greenhouse effect and its relationship to global warming.	All parts of the student's graph are present and correctly labeled including the axis labels, titles and scales. The student uses data to explain the greenhouse effect and its relationship to global warming.