PhET Greenhouse Effect

Objective: Describe how the "greenhouse effect" affects temperature on the earth and to use evidence to support whether the "greenhouse effect" is good or bad for the earth.

Introduction: Global warming is perhaps the "hottest" topic in today's headlines. The cause of warming is usually blamed on the "greenhouse effect" or "greenhouse gases." The following simulation will allow you to first examine how the "greenhouse effect" works in a greenhouse. You will then experiment with a simulation of the earth's atmosphere where the concentration of greenhouse gases can be varied. Y will use the results of the two simulations to describe how the "greenhouse effect" affects temperature on the earth and discuss whether the "greenhouse effect" is good or bad for the earth. You will compare the levels of greenhouse gases to different periods in the earth's history and examine their effects. Finally, you will examine different molecules that make up our atmosphere and determine which ones are better at absorbing photons.

Before diving into the whole issue of global warming, try to picture sitting in an enclosed car on a cold but sunny day … pretty comfortable, isn't it. Now imagine sitting in that same car on a hot, sunny day. Don't hold that image too long. You'll fry just thinking about it. Now you know why it is so important not to leave children or pets in a car unattended.

NOTE: For electronic submission, type your answers in the blocks provided. If you intend to turn in a hardcopy, ensure you have enough room for each answer prior to printing.

1. Hypothesize why the inside of a car feels so much warmer than its surroundings on sunny days.

   Answer:

2. Go to http://phet.colorado.edu/en/simulation/greenhouse. Click "Run Now"

Part I: A Greenhouse Simulation

1. Select the "Glass Layers" tab.
2. What do the yellow stars represent?

   Answer:

3. What do the red stars represent?

   Answer:

4. Both the yellow and red stars represent forms of energy in the form of photons: the yellow are visible light, the red are heat.
5. Record the approximate temperature "inside the greenhouse" before adding glass panes.

   Answer:

6. Add one glass pane. What do the sunlight photons do when they hit the glass from the top?

   Answer:

7. What do the infrared photons do when they hit the glass from the bottom? Be specific.

Answer:

8. What is the new temperature "inside the greenhouse?"

Answer:

9. Based on the observations of the photons, why does the temperature go up so much?

Answer:

10. What happens to the temperature as additional glass panes are added?

Answer:

11. Explain why this happens by observing the photons.

Answer:

12. Before proceeding to the earth, predict how what you have discovered regarding greenhouses might apply to the earth and its atmosphere.

Answer:

Part II: The Earth Simulation

1. Select the "Greenhouse Effect" tab. Which greenhouse gases are considered by the simulation?

Answer:

2. Which time period do the default conditions represent?

Answer:

3. The thermometer represents the average global temperature. What is the average global temperature for the "today" simulation?

Answer:

4. Is the behavior of the photons more similar to the greenhouse simulation with or without glass panes?

Answer:

5. Reduce the greenhouse gas concentration to "None". Is the behavior of the photons more similar to the greenhouse simulation with or without glass panes?

Answer:

6. What is the average global temperature?

Answer:

7. Considering the behavior of the photons, why does the temperature drop so much?

Answer:

8. Increase the greenhouse gas concentration to "Lots." What is the average global temperature?

Answer:

9. Considering the behavior of the photons, why does the temperature increase?

Answer:

Part III: Incremental Analysis.

Write a paragraph that answers the following questions:

1. How does the "greenhouse effect" affect temperature on the earth?

Answer:

2. How is the "greenhouse effect" similar to blankets on a bed?

Answer:

3. Is the "greenhouse effect" good or bad for the earth?

Answer:

Part IV: Analyze how Greenhouse Gases affect Earth's temperature and identify processes that might increase or decrease Earth's temperature

Ice Age

1. Click on the "Ice Age" button and record the minimum temperature. _____
2. Record: CO2 _____ CH4 _____ N2O _____
3. What happens to the sunlight photons as they hit the ground? Are all of the sunlight photons being reflected back into space?

Answer:

4. What happens to the temperature when you add clouds?

Answer:

5. How are the photons affected by adding clouds? _____

Answer:

1750

1. Click on the "1750" button and record the minimum temperature. _____
2. Record: CO2 _____ CH4 _____ N2O _____
3. What happens to the sunlight photons as they hit the ground?

Answer:

4. What happens to the temperature when you add clouds?

Answer:

5. How are the photons affected by adding clouds? _____

Answer:

Today

1. Click on the "Today" button and record the minimum temperature. _____
2. Record: CO2 _____ CH4 _____ N2O _____
3. What happens to the sunlight photons as they hit the ground?

Answer:

4. What happens to the temperature when you add clouds?

Answer:

5. How are the photons affected by adding clouds? _____

Answer:

Comparison

1. Describe how, according to the model, the effects of Greenhouse Gases on the Earth's atmosphere have changed from the Ice Age to today.

Answer:

2. What assumptions do you think the model is making? Do you think those assumptions are valid?

Answer:

3. What would happen if there were no Greenhouse gases? (Adjust the Greenhouse Gas Concentration Level to None.)

Answer:

4. What will happen if Greenhouse gases increase in the future? (Adjust the Greenhouse Gas Concentration Level to Lots.)

Answer:

5. Identify some natural or human processes that might increase or decrease the amount of greenhouse gases in the atmosphere.

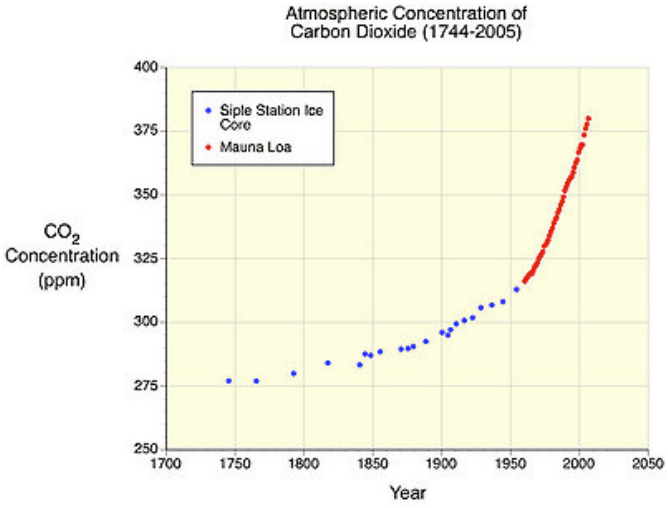
Answer:

Part V: Scientific Question: Which atmospheric gas (CH_4, CO_2, H_20, N_2, or 0_2) is the best absorber of infrared photons?

Lab Background Information

Table 1: *Average composition of the Earth's atmosphere up to an altitude of 25 km.*

Gas Name	Chemical Formula	Percent Volume
Nitrogen	N_2	78.08%
Oxygen	O_2	20.95%
*Water	H_2O	0 to 4%
Argon	Ar	0.93%
*Carbon dioxide	CO_2	0.0360%
Neon	Ne	0.0018%
Helium	He	0.0005%
*Methane	CH_4	0.00017%
Hydrogen	H_2	0.00005%
*Nitrous oxide	N_2O	0.00003%
*Ozone	O_3	0.000004%
* variable gases		



- **CH_4** is a very strong greenhouse gas. Since 1750, methane concentrations in the atmosphere have increased by more than 150%. The primary sources for the additional methane added to the atmosphere (in order of importance) are: rice cultivation; domestic grazing animals; termites; landfills; coal mining; and, oil and gas extraction.

- The volume of **CO_2** has increased by over 35% in the last three hundred years. This increase is primarily due to human activities such as combustion of fossil fuels, deforestation, and other forms of land-use change. It is now fact—the increase is causing global warming through an enhancement of the greenhouse effect.

- **H_20** (water vapor) varies in concentration in the atmosphere both spatially and temporally. Water vapor has several very important functional roles on our planet. For example, the condensation of water vapor creates precipitation that falls to the Earth's surface providing needed fresh water for plants and animals. Additionally, it helps warm the Earth's atmosphere through the greenhouse effect.

- **N_2** is removed from the atmosphere and deposited at the Earth's surface mainly by specialized nitrogen fixing bacteria, and by way of lightning through precipitation. The addition of this nitrogen to the Earth's surface soils and various water bodies' supplies much needed nutrition for plant growth.

- **O_2** is exchanged between the atmosphere and life through the processes of photosynthesis and respiration. Photosynthesis produces oxygen when carbon dioxide and water are chemically converted into glucose with the help of sunlight.

- Remember, infrared radiation is heat.

Tools:

1. Click on the "Photon Absorption" Tab
2. Observe what happens when you move the slider on the photon emitter.
3. Observe what happens when you change which atmospheric gas you are examining.
4. After examining how this application works for a few minutes, you are now ready to begin your experiment!

Design and Execute An Experiment:

1. Develop a methodology for testing the different elements for photon absorption (infrared only). Write the steps for your procedure below:

   a.

   b.

   c.

   d.

   e.

   f.

2. Summarize your results in the following table (disregard error and uncertainty, but ensure you are clear in what your measurements consist of).

	CH_4	**CO_2**	**H_20**	**N_2**	**0_2**

3. Write a conclusion that answers the question, "Which atmospheric gas (CH_4, CO_2, H_20, N_2, or 0_2) is the best absorber of infrared photons?"