

SI Environmental Science - Full Discipline Demo

The Greenhouse Effect

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Environmental Science - Full Discipline Demo
Course	SI Environmental Science - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

☼ Climate	Heat energy emitted from earth's surface	1
☼ Greenhouse effect	Molecule that interacts with infrared photons in the atmosphere	2
☼ Greenhouse gas	Light energy emitted from the sun	3
☼ Infrared radiation	Description of the average atmospheric conditions of an area for several decades	4
☼ Solar radiation	Description of short-term changes in atmospheric temperature, humidity, precipitation, and wind speed	5
☼ Weather	The process of the atmosphere trapping heat and warming the earth	6

Correct answers:

- 1 Infrared radiation 2 Greenhouse gas 3 Solar radiation 4 Climate
5 Weather 6 Greenhouse effect

Categorize each statement as true or false.

True	False
1	2

⚡
More carbon dioxide is currently being produced from human activity than can be absorbed by plants.

⚡ Nitrous oxide can remain in the atmosphere for over 100 years.

⚡ Human activity leads to significant increases of water vapor in the atmosphere.

⚡
An increase in earth's temperature by 1.0°C has produced little impact on the environment.

Correct answers:

1

More carbon dioxide is currently being produced from human activity than can be absorbed by plants.

Nitrous oxide can remain in the atmosphere for over 100 years.

2

Human activity leads to significant increases of water vapor in the atmosphere.

An increase in earth's temperature by 1.0°C has produced little impact on the environment.

Exploration

Most ____ radiation interacts with earth's atmosphere and is either trapped there or reflected back towards earth's surface.

- ☒ longwave ✓
- ☐ shortwave
- ☐ solar
- ☐ higher energy

____ interacts with infrared radiation and is considered a greenhouse gas.

- ☐ Carbon dioxide
- ☐ Methane
- ☐ Water vapor
- ☒ All of the above ✓

____ is the most abundant greenhouse gas in earth's atmosphere.

- ☒ Water vapor ✓
- ☐ Carbon dioxide
- ☐ Methane
- ☐ Oxygen

Human activities contribute to the concentration of ____ in the atmosphere.

- ☐ carbon dioxide
- ☐ methane
- ☐ nitrous oxide
- ☒ All of the above ✓

Carbon dioxide, methane, and nitrous oxide concentrations in earth's atmosphere have increased exponentially since 1750.

- ☒ True ✓
- ☐ False

Exercise 1

How do the results from the simulation support the relationship between human-emitted greenhouse gases and current climate change? Reference Data Tables 1 and 2 in your answer.

Current climate change is directly associated with increased concentrations of human-emitted greenhouse gases since 1750. In the simulation, concentrations of carbon dioxide, methane, and nitrous oxide increased by 33%, 150%, and 20% respectively between 1750 and today, as listed in Data Table 2. These increases are directly related to a 1°C increase in average global temperature in the simulation, as recorded in Data Table 1.

What were the effects of adding clouds to the simulation runs? Reference Data Table 1 and Panel 2 in your answer.

Clouds interacted with both sunlight and infrared photons in the simulation. Inbound sunlight photons were deflected back into space by clouds, while outbound infrared photons were deflected back towards earth, as recorded in Panel 2. In all simulation runs, except for the one with no greenhouse gases, clouds had the effect of lowering temperatures by an average of 2°C, as recorded in Data Table 1.

How might the environment be impacted if the earth warmed to the temperatures recorded for maximum greenhouse gas concentrations in Data Table 1?

Based on the simulation, the maximum concentrations of greenhouse gases would result in a 4°C increase in average global temperatures. This increase would be greater than the increase since the last ice age, and result in accelerated ocean warming, ice sheet disappearance, glacial melting, decreased snow cover, rising sea levels, and increased extreme weather events.

Based on your knowledge of the human-caused sources of greenhouse gases, what can you do as an individual to reduce emissions of these compounds?

Note to Instructor: This question is designed to create reflection, so students' answers will vary. Ideal answers should include a personal reduction in transportation and energy sources that rely on the combustion of fossil fuels, which emit both carbon and nitrous oxides into the atmosphere. Furthermore, a reduction of personal wastes and reliance on large-scale commercial agriculture can reduce methane emissions through an overall reduction in large areas of decomposition.

Data Table 1: Simulation Temperature Response to Gas Concentrations
(SAMPLE ANSWER BELOW)

Clouds	No greenhouse gases (°C)	1750 concentrations (°C)	Today concentrations (°C)	Maximum concentrations (°C)
No	-17	16	17	21
Yes	-14	13	14	19

Data Table 2: Greenhouse Gas Composition
(SAMPLE ANSWER BELOW)

Date	H ₂ O (% humidity)	CO ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
1750	70	280	0.730	0.270
Today	70	338	1.843	0.317

Panel 1: Observations with No Clouds
(SAMPLE ANSWER BELOW)

Sunlight photons travel toward earth and produce infrared photons as the surface warms. Infrared photons travel upward into earth's atmosphere. With no greenhouse gases, all infrared photons exit the atmosphere. As more greenhouse gases are added to the atmosphere, increasing numbers of infrared photons are deflected from the atmosphere back towards the surface of the earth.

Panel 2: Observations with Clouds
(SAMPLE ANSWER BELOW)

Clouds deflected incoming sunlight photons and outgoing infrared photons, resulting in fewer sunlight photons hitting the earth's surface, but more infrared photons being deflected back to the surface at all greenhouse gas concentrations.

Competency Review

Greenhouse gases in the atmosphere trap ____ radiation and warm the Earth.

- ☒ infrared ✓
 - ☐ solar
 - ☐ shortwave
 - ☐ higher energy
-

Carbon dioxide, methane, and water vapor are composed of two different types of atoms.

- ☒ True ✓
 - ☐ False
-

____ can act as both a greenhouse gas and a cooling agent in the atmosphere.

- ☐ Carbon dioxide
 - ☐ Nitrous oxide
 - ☒ Water vapor ✓
 - ☐ Methane
-

____ contributes 9-26% of the greenhouse effect and remains in the atmosphere for over 30 years.

- ☒ Carbon dioxide ✓
 - ☐ Methane
 - ☐ Nitrous oxide
 - ☐ Water vapor
-

Earth's current climate change event is most closely associated with changes in ____.

- ☐ Earth's orbit
- ☒ greenhouse gas levels ✓
- ☐ solar irradiance
- ☐ oxygen levels

Climate change can be observed as ____.

- ☐ retreating glaciers
- ☐ shrinking ice sheets
- ☐ warming oceans
- ☒ All of the above ✓

When utilizing a greenhouse effect simulation, infrared photons increase in number as greenhouse gas concentrations increase.

- ☒ True ✓
- ☐ False

When utilizing a greenhouse effect simulation, clouds interact with both sunlight and infrared photons.

- ☒ True ✓
- ☐ False

The results of the greenhouse effect simulation predict that global average temperatures will increase by another ____ °C at maximum human-emitted greenhouse gas concentrations.

- ☐ 1
- ☐ 2
- ☒ 4 ✓
- ☐ 8

Extension Questions

The warming effects of greenhouse gases have been unsuccessfully modeled by placing air, pure carbon dioxide, methane, and nitrous oxide in sealed jars and measuring temperature change within the jars when exposed to a light source. When using this model, the temperatures in all jars rise rapidly and exceed atmospheric temperatures recorded on earth. Apply your knowledge of greenhouse gases to explain why this approach is inappropriate for modeling how greenhouse gases retain heat in earth's atmosphere.

(SAMPLE ANSWER BELOW)

The model is inappropriate because the glass jar would trap all infrared rays, similar to the walls of a greenhouse, preventing all heat from leaving the jar. Greenhouse gases interact with infrared rays to prevent most heat (90%) from leaving earth's atmosphere. Their effect would not be realized because the jar would trap all infrared radiation, regardless of the gas mixture inside.