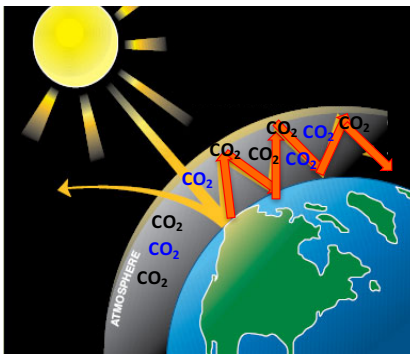
Name _____ Teacher _____ Date _____

Activity 3.2 The Greenhouse Effect Reading

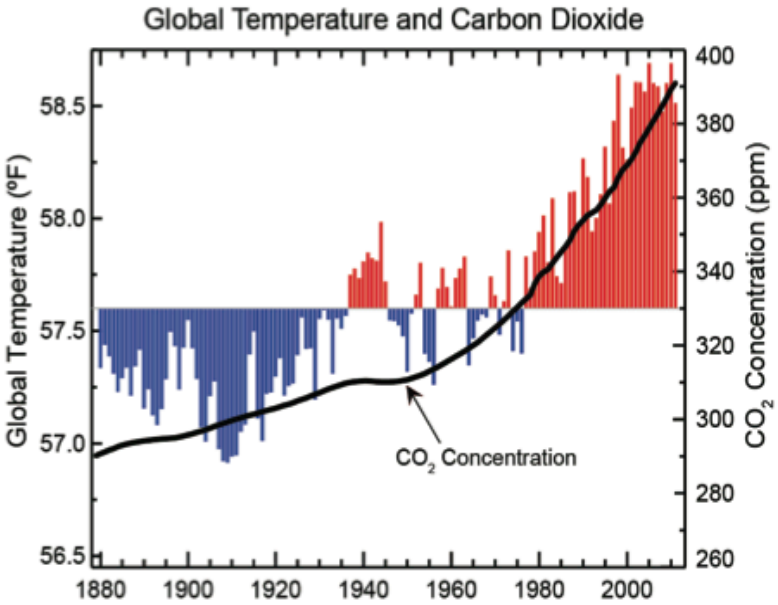


The Greenhouse Effect. Just as the composition of your clothing affects the movement of heat energy away from your body into the surrounding air, the composition of the atmosphere affects how the temperature of the earth is regulated. The temperature of our air depends on the balance between solar radiation (mostly visible light) that warms the Earth up and invisible infrared (IR) radiation that cools the Earth down by leaving the Earth and going into outer space. The gases in the atmosphere mostly let solar radiation pass right through, but the story about how they interact with infrared radiation is more complicated—and that's a story we need to tell.

Most of the atmosphere is comprised of nitrogen gas (N_2) and oxygen gas (O_2), but these gases do not change the rate at which energy moves from the surface of the earth into space. On the other hand, some gases like carbon dioxide (CO_2) and methane (CH_4) affect how energy (in the form of infrared radiation) is able to move from the earth's surface into space. These kinds of gases are called *greenhouse gases* because (like a greenhouse or a car on a hot summer day) they allow visible light radiation to enter the atmosphere but slow the leaving infrared radiation.

This naturally occurring phenomenon is called the *greenhouse effect* and is necessary for life on Earth. Without greenhouse gases the Earth would be freezing cold! However, if the concentration of greenhouse gases in the atmosphere increases *too much*, it will cause the planet to reach temperatures that damage our ecosystems. Just like leaving a car's windows closed on a hot summer day can cause the temperature inside the car to rise, increasing the concentration of CO_2 and other greenhouse gases in the atmosphere can cause the temperature of the planet to increase.

Dr. Charles Keeling was the first person in the world to accurately determine the rate at which carbon dioxide in the air was gradually increasing each year. More CO_2 absorbs more infrared radiation, so the average temperature of the Earth is increasing. There are still hot places and cold places, and there are still hot days and cold days, but as the graphs shows, the Earth's overall average temperature has been increased substantially in the last 50 years.

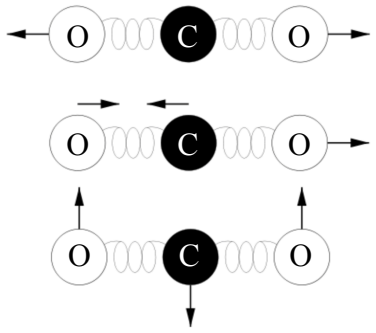


Greenhouse effect simulation. The PhET Greenhouse Effect Simulation allows you to change the atmospheric greenhouse gas concentration, observe how these changes affect the movement of infrared photons into space, and determine how this ultimately affects temperature. If your instructor has not already done so, you will need download the PhET simulation onto the computers or device that you will be using. To do so, visit https://phet.colorado.edu/en/simulation/greenhouse . Follow the instructions on the worksheet for this activity and complete the corresponding questions.

Digging Deeper

What's different about greenhouse gases?

Why do some gases slow the loss of heat through the atmosphere while others don't? Some molecules absorb infrared light by converting the light energy into the energy of vibration. Molecules with more than two atoms and those with different kinds of atoms can vibrate in multiple ways, allowing them to absorb and re-emit infrared radiation. Whether or not a molecule can absorb infrared radiation leaving the Earth depends on these vibrations.



The atoms on a CO2 molecule have more complex vibration modes that allow them to absorb infrared light and emit it in any direction. (*Source: scied.ucar.edu*)

The atoms on N_2 and O_2 molecules are identical and can only move closer or further apart. This is not complex enough to enable interaction with infrared radiation. On the other hand, there are multiple kinds of atoms on a CO_2 molecule, and they have complex vibrational modes. This allows CO_2 to absorb infrared light and emit it in any direction. This slows the loss of this energy from the earth's atmosphere. Increasing the levels of greenhouse gases that exist in the atmosphere makes it more difficult for infrared radiation to leave the earth (similar to the effect of slowly closing car windows on a sunny day).

- Lean more about Americans' attitudes toward climate change("Global Warming's Six Americas"): https://www.americanprogress.org/issues/green/reports/2009/05/19/6042/global-warmings-six-americas/
- This website has an animated GIF that models infrared radiation and molecule vibration. It uses "absorption-emission-absorption" and vibrations to explain this phenomenon. https://scied.ucar.edu/molecular-vibration-modes
- This website from the American Chemical Society explains the phenomenon in more advanced terms, including the Global Warming Potential for each greenhouse gas molecule: http://www.acs.org/content/acs/en/climatescience/greenhousegases/properties.html
- For more information about how this creates a feedback loop, see this website from the American Chemical Society: http://www.acs.org/content/acs/en/climatescience/atmosphericwarming/climatsensitivity.html
- This 10 minute video of Richard Feynman explaining "jiggling atoms" might be helpful for students trying to understand how radiation interacts with atoms to produce heat: https://www.youtube.com/watch?v=NsdCzujHqAk