

# The Carbon Cycle and the Greenhouse Effect

## Data Based Question

### Background

When solar energy reaches the earth, some of it is reflected by the atmosphere. Most of the remainder passes through the atmosphere, reaching the Earth's surface. At the surface, some of the energy is reflected and some is absorbed. As the surface of the earth absorbs solar energy, the surface warms up and then radiates energy, mostly as infrared, back into the atmosphere towards space. Some of the naturally occurring gases in the Earth's atmosphere absorb some of this infrared energy. These gases warm, and in turn radiate infrared energy of their own in all directions, some of which is absorbed by the surface giving it additional energy. This process is the natural greenhouse effect.

Large amounts of carbon dioxide gas enter the atmosphere from the respiration of organisms. The gas is absorbed from the atmosphere during the process of photosynthesis. Over the long history of life on Earth, the different stages in the carbon cycle came to a long term balance in which the amount of carbon dioxide in the atmosphere was approximately 280 parts per million (ppm). Since 1850 however, the combustion of fossil fuels by human activity has raised the amount of carbon dioxide in the air. This increase is now being monitored closely because of the important role that carbon dioxide plays in trapping heat radiating from the Earth's surface.

In this activity, you will graph and analyze the relationships amount carbon dioxide concentration, combustion of fossil fuels and changes in the Earth's temperature using real data. From this information, you will determine if there are any significant trends or relationships among the data.

### \*Problem:

What is the relationship among carbon dioxide concentration, combustion of fossil fuels and world temperature?

### \*Predictions:

Predict how the combustion of fossil fuels might affect a) the concentration of carbon dioxide in the atmosphere and b) world temperature. Give reasons for your predictions.

### \*Data Presentation

Create titled and labeled graphs of:

- Carbon dioxide concentration in the atmosphere since between 1010 and 2006 (note: use a different color line to distinguish data collected directly and data measured through ice core samples. Include a key to the colors used in your graph).
- The variation of world temperature from the mean between 1870 and 2005.

Your graphs can be aligned horizontally or vertically on the page. You must determine best scale for your axis; your scale intervals do not have to start at 0. Be sure each graph has a detailed title.

Data for the graphs can be found at the following websites:

1. Data for atmospheric CO<sub>2</sub> at Mauna Loa is available for 1958 – 2012. Record the CO<sub>2</sub> data for your birth month only. CO<sub>2</sub> concentration is expressed as a mole fraction in dry air, micromol/mol, abbreviated as ppm. Mauna Loa Observatory is located far from any pollution sources affecting the gases of interest. The observatory is on the Island of Hawaii at an elevation of 3397 m on the northern flank of the dormant Mauna Loa volcano. Established in 1957, Mauna Lao Observatory has grown to become the premier long-term atmospheric monitoring facility on earth.
2. Historical data of atmospheric CO<sub>2</sub> for 1010 – 1975 is available from the DSS ice cores. Glaciers are found today on mountains and in the Arctic and Antarctic. In these permanently frozen areas,

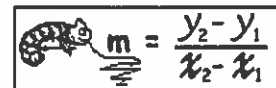
each year's snowfall piles up on top of snow that fell the year before. As the centuries pass, the layers of snow become more deeply buried, and are turned into ice by the pressure of the snow above it. Inside each ice crystal, gases from the atmosphere are locked and buried like tiny time capsules. By carefully drilling out samples of ice from different depths below the surface of a glacier, scientists can sample the atmosphere from different times in the past. Using this technique, scientists have been able to build up a picture of variations in the concentration of carbon dioxide in the atmosphere over the past 150,000 years.

3. Temperature data for 1880 through 2012 can be found here. The data is recorded as shown as variation from the mean global atmospheric temperature between the years of 1951 and 1980. The global mean temperature for 1951-1980 was 14.0 °C. A value of -0.41 in the table means the temperature was 0.41 degrees less than the global mean of 14.0. So, the temperature would be recorded as 13.59 °C. **Record the temp data for your birth month only.**

### \*Analysis and Interpretation

Answer the following questions in complete sentences in a manner that implies what question was being asked. Show your work if a calculation is involved.

1. What was the average atmospheric CO<sub>2</sub> concentration prior to the industrial revolution (1830)?
2. On the atmospheric CO<sub>2</sub> concentration graph, determine slopes (m) of your line before and after the industrial revolution. What does this slope represent?
3. Calculate the percentage change in atmospheric CO<sub>2</sub> concentration
  - Between 1010 and 1830
  - Between 1830 and 2011


$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Simply **subtract** the older measurement from the newer measurement, and then **divide** by the older measurement. **Multiply** the result by 100 and slap a % sign on it. That's your percent change.

4. Describe the pattern of change since 1830 in:
  - Carbon dioxide concentration in the atmosphere
  - The amount of carbon dioxide produced by the combustion of fossil fuels
  - World temperature.
5. Do these data support or falsify your predictions, or do neither? Explain your answer.
6. Do the data prove that increases in the world temperature are caused by increases in carbon dioxide production? Explain your answer.
7. Based on the data in your graphs, predict for the year 2020
  - a. The amount of carbon dioxide produced by the combustion of fossil fuels.
  - b. Atmospheric carbon dioxide concentration.
  - c. Increase in world temperature.

# Global Warming

## What is global warming?

1. What is global warming?
2. What happens to the sunlight that is not absorbed by the surface of the earth?
3. In your own words, explain the greenhouse effect.
4. What is the natural role of greenhouse gases?
5. List examples of greenhouse gases.

## What evidence is there for global warming?

6. How has the increase in temperature of Earth been measured since 1860?
7. How can the Earth's long term temperature changes be measured indirectly?
8. What consequences the warmer temperatures on Earth have already been observed?
9. How many million square kilometers of arctic sea ice melted between the years 1900 and 2000?

## What are the causes of global warming?

10. What do most scientists believe is the cause of global warming?
11. By what percent have carbon dioxide and methane concentrations risen since the 1800's?
12. How do we know that the amount of carbon dioxide in the environment has been increasing since the 1700's?

13. What are thought to be the causes of the increase in greenhouse gases in the atmosphere?

14. Which five countries produce the most greenhouse gas emission?

15. Mathematical models predict that the amount of carbon dioxide in the atmosphere will increase to what range of levels by 2100?

**What are the effects of global warming?**

16. Mathematical models predict that the temperature of Earth will increase by how many degrees by 2100?

17. List eight potential effects of a 1° C rise in Earth's average temperature.

18. Which country is most at risk if the oceans rise by just 1 meter?

19. Which US city would have the highest number of heat related mortalities?

20. What are possible effects of global warming in the Puget Sound region?

**What can you do to reduce global warming?**

21. What are some potential alternative energy sources?

22. How will you become more energy efficient?

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