

2007

## Carbon Dioxide in the Atmosphere

STORM Project

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# Chemistry and Environmental Sciences

## Carbon Dioxide in the Atmosphere

Name: \_\_\_\_\_

**Objectives:** Students learn the importance of carbon dioxide in the atmosphere.

### National Science Education Standard:

As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry. As a result of their activities in grades 9-12, all students should develop understanding of matter, energy, and organization in living systems. As a result of their activities in grades 9-12, all students should develop an understanding of energy in the earth system and geochemical cycles.

### Materials:

Baking Soda ( $\text{NaHCO}_3$ )  
Vinegar  
2000 ml Beaker  
500 ml Beaker  
Two Candles  
Matches  
Five Gallon Fish Aquarium

Five Thermometers  
Computer  
CAMEO Computer Simulation  
ALOHA Computer Simulation  
MARPLOT Computer Simulation  
Clear Plastic Wrap

### Vocabulary:

Combustion  
Density  
Sink  
Respiration  
Carbon Dioxide  
Anthropogenic

Carbon Cycle  
Greenhouse Effect – all gasses  
Transpiration  
Sources (point / non-point)  
Displacement / Volume

Atmosphere layers:  
Troposphere  
Stratosphere  
Mesosphere  
Thermosphere

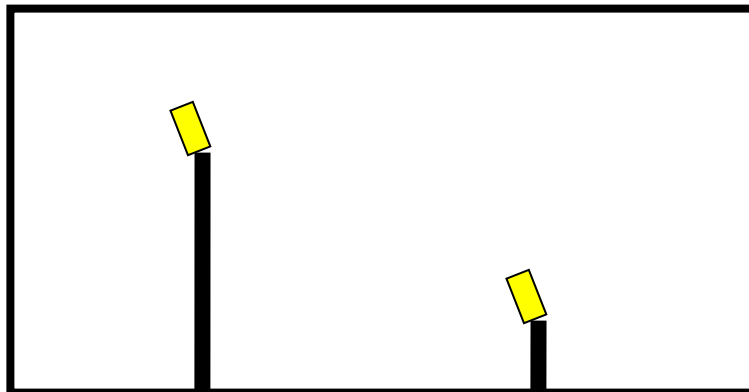
### Engage:

Name the sources of carbon dioxide in the atmosphere. Sources may be natural (geological processes) or anthropogenic. Draw the carbon cycle including all of your point sources, non-point sources, and sinks.

**Explore:**

The teacher will place two candles of different heights (see figure one below) in the bottom of the five gallon fish aquarium then light the candles with a match. The teacher will add 100 ml of vinegar to 20 grams of baking soda to a 2000 ml beaker. Pour the gas that is produced into the fish aquarium leaving the liquid in the 2000 ml beaker.

Figure 1



Answer the following questions below.

- 1) What happens to the two flames in the aquarium?
  
  
  
  
  
  
  
  
  
  
- 2) Hypothesize a cause for what you observed after the gas entered the aquarium.
  
  
  
  
  
  
  
  
  
  
- 3) Hypothesize what would happen if a small mammal were in the bottom of the aquarium. Explain.
  
  
  
  
  
  
  
  
  
  
- 4) Discuss the properties of carbon dioxide and how these properties affect the atmosphere.

**Explain:**

The teacher will obtain five 500 ml beakers with clear wrap covers. Place a thermometer in the bottom of each of the beakers. Place the appropriate amount of vinegar and baking soda in the bottom of each of the beakers (see table 1). Mix the vinegar and bleach. Upon mixing the two ingredients cover the beaker with the clear plastic wrap. Place each of the beakers in sunlight and monitor the temperature as time progresses. Record your data in tables 2A-2E.

Table 1	<u>Beaker Number</u>	<u>Vinegar (ml)</u>	<u>Baking Soda (g)</u>
	Beaker One	30	0
	Beaker Two	30	1
	Beaker Three	30	2
	Beaker Four	30	3
	Beaker Five	30	4

Table 2-A

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-B

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-C

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-D

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-E

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Graphing: Make a line graph of your data.

Answer the following questions below.

What evidence is there that carbon dioxide is being produced?

Examining your graph, what evidence do you see that would lead you to believe that there are different amounts of carbon dioxide in each of the beakers?

How does temperature change with time for each of the five beakers? By comparing your data with another resource, does your data reflect what was expected? Why or why not?

**Extend:**

You will be using CAMEO computer software to forecast the effect of a carbon dioxide release in your hometown.

- 1) Launch CAMEO application from the CAMEO folder.
- 2) We'll briefly explore some of the Navigator options.
- 3) Launch ALOHA from the CAMEO Navigator display. We will practice with the following scenario. You will need this information for the SiteData and SetUp menus.

A tractor-trailer containing liquid carbon dioxide has crashed on the main highway through town and has developed a sudden leak. The tank, located inside of your town is a horizontal cylinder 10 feet in diameter and 40 feet long. The tank was 75% full (by volume) at the time the leak developed from a rectangular hole that is one foot by five feet and is located 5% of the way to the top of the tank. Weather conditions at the time of the release are sunny and dry with a temperature of 85°F and an anemometer level wind from 45<sup>0</sup> (NE) at 25 knots.

- 4) Using the above information, complete the SiteData input. Using the Location Information dialog box, Add an entry for 'Your Town' using the appropriate latitude and longitude. Then Select this location from the Location Information menu.
- 5) Complete the Set Up menu options. Select the Chemical Input first, then do the Atmospheric (you'll want the User Input option), and finally the Source input.
  - a) In what phase did the carbon dioxide escape?
- 6) Go to the Display menu and select Footprint. Use ERPG 3, 2, and 1 for the red, orange, and yellow footprints respectively.
  - a) Discuss the meaning of each ERPG (use the Help button).
- 7) We now want to transfer the footprint onto a map. Go to Aloha's Help menu (Contents) and then select Maps from the list of available topics. Copy the web location where you can obtain MARPLOT maps and paste it into a browser session. Open the file for your county. In the Filzip dialog box, select the .zip file and then the Extract menu option and place in the prescribed folder. Then rename it YOURCOUNTY.MAP.
- 8) Launch MARPLOT from the CAMEO Navigator display. From the View menu, select Go To View, then Map List, then Find New Map. Select the YOURCOUNTY County map and then Go to View.
- 9) Just below the menu bar, select the little down arrow to the left of the term Focus Pt. Then select Go to Lat/Long and enter the values for the spill location.
- 10) From the Sharing menu, select ALOHA and then Set Source Pt.
- 11) You can zoom by selecting the + magnifying glass at the left side of the display.

**Analysis:**

Describe the shape of the proposed evacuation zone.

What major structures are in the evacuation zone?

What are some of the possible health effects of those who do not evacuate the evacuation zone?

What factors effect how large the evacuation zone will be?

## Carbon Dioxide in the Atmosphere

(Teacher Copy)

**Objectives:** Students learn the importance of carbon dioxide in the atmosphere.

### **National Science Education Standard:**

As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry. As a result of their activities in grades 9-12, all students should develop understanding of matter, energy, and organization in living systems. As a result of their activities in grades 9-12, all students should develop an understanding of energy in the earth system and geochemical cycles.

### **Materials:**

Baking Soda ( $\text{NaHCO}_3$ )	Five Thermometers
Vinegar	Computer
2000 ml Beaker	CAMEO Computer Simulation
500 ml Beaker	ALOHA Computer Simulation
Two Candles	MARPLOT Computer Simulation
Matches	Clear Plastic Wrap
Five Gallon Fish Aquarium	

### **Vocabulary:**

**Teacher Notes:** <http://puzzlemaker.com> is a possible source for vocabulary development activity.

Combustion	Carbon Cycle	Atmosphere layers:
Density	Greenhouse Effect – all gasses	Troposphere
Sink	Transpiration	Stratosphere
Respiration	Sources (point / non-point)	Mesosphere
Carbon Dioxide	Displacement / Volume	Thermosphere
Anthropogenic		

### **Teacher Notes:**

To study the importance of carbon dioxide in the atmosphere students will explore the carbon cycle, its role in global warming, and carbon dioxide's effect on combustion and respiration.

### **Engage:**

The teacher will lead a classroom discussion over the various sources of carbon dioxide in the atmosphere and at the end develop a classroom generated carbon cycle. Name the sources of carbon dioxide in the atmosphere. Sources may be natural (geological processes) or anthropogenic. Draw the carbon cycle including all of your point sources, non-point sources, and sinks.

### **Explore:**

The teacher will place two candles of different heights (see figure one below) in the bottom of the five gallon fish aquarium then light the candles with a match. The teacher will add 100 ml of vinegar to 20 grams of baking soda to a 2000 ml beaker. (Teacher Note: test run because of the height of the candle dictates the amount of carbon dioxide needed to extinguish the candle flame.) Pour the gas that is produced into the fish aquarium leaving the liquid in the 2000 ml beaker. (This should extinguish the lowest of the

two candle flames caused by the presence of the carbon dioxide as demonstrated by the dashed line in figure two below.)

Figure 1

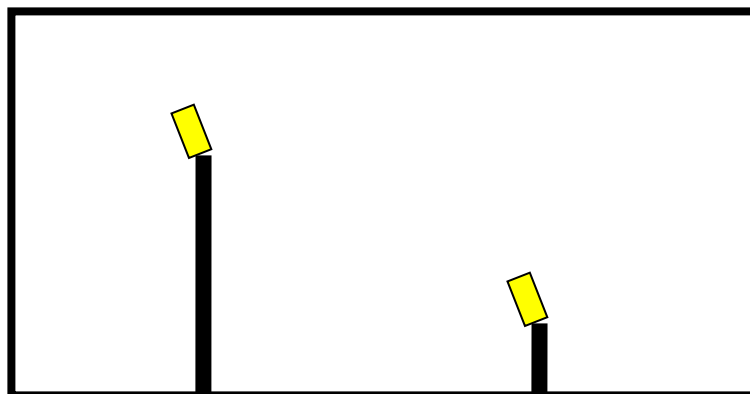
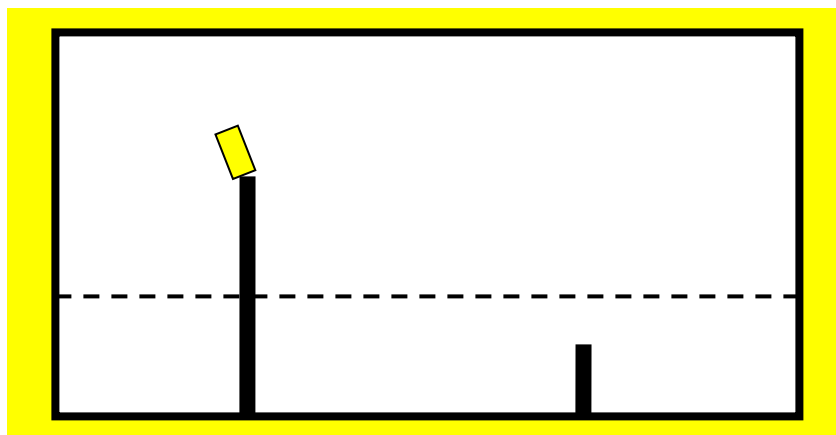


Figure 2



Answer the following questions below on a separate sheet of paper.

- 1) What happens to the two flames in the aquarium?
- 2) Hypothesize a cause for what you observed after the gas entered the aquarium.
- 3) Hypothesize what would happen if a small mammal were in the bottom of the aquarium. Explain.
- 4) Discuss the properties of carbon dioxide and how these properties affect the atmosphere.

**Explain:**

The teacher will obtain five 500 ml beakers with clear wrap covers. Place a thermometer in the bottom of each of the beakers. Place the appropriate amount of vinegar and baking soda in the bottom of each of the beakers (see table 1). **These amounts may need to be adjusted.** Mix the vinegar and bleach. Upon mixing the two ingredients cover the beaker with the clear plastic wrap. Place each of the beakers in sunlight and monitor the temperature as time progresses. Record your data in tables 2A-2E.

Table 1	<u>Beaker Number</u>	<u>Vinegar (ml)</u>	<u>Baking Soda (g)</u>
	Beaker One	30	0
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Table 2-A

Time (min)	Temperature (°C)
1	
2	
3	
4	
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Table 2-B

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-C

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-D

Time (min)	Temperature (°C)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Table 2-E

Time (min)	Temperature (°C)
1	
2	
3	
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7	
8	
9	
10	

Graphing: Make a line graph of your data.

Answer the following questions below on a separate sheet of paper.  
 What evidence is there that carbon dioxide is being produced?

Examining your graph, what evidence do you see that would lead you to believe that there are different amounts of carbon dioxide in each of the beakers?

How does temperature change with time for each of the five beakers? By comparing your data with another resource, does your data reflect what was expected? Why or why not?

**Extend:**

You will be using CAMEO computer software to forecast the effect of a carbon dioxide release in your hometown.

1) Launch CAMEO application from the CAMEO folder.

2) We'll briefly explore some of the Navigator options.

Teacher Note: It is recommended that the teacher explore the CAMEO/ALOHA/MARPLOT tutorial located at: [http://www.meted.ucar.edu/dispersion/cam\\_hys/navmenu0.htm](http://www.meted.ucar.edu/dispersion/cam_hys/navmenu0.htm)

3) Launch ALOHA from the CAMEO Navigator display. We will practice with the following scenario. You will need this information for the SiteData and SetUp menus.

A semi tractor trailer containing liquid carbon dioxide has crashed on the main highway through town and has developed a sudden leak. The tank, located inside of your town is a horizontal cylinder 10 feet in diameter and 40 feet long. The tank was 75% full (by volume) at the time the leak developed from a rectangular hole that is one foot by five feet and is located 5% of the way to the top of the tank. Weather conditions at the time of the release are sunny and dry with a temperature of 85°F and an anemometer level wind from 45<sup>0</sup> (NE) at 25 knots.

4) Using the above information, complete the SiteData input. Using the Location Information dialog box, Add an entry for 'Your Town' using the appropriate latitude and longitude. **Teacher Note: Post prepared latitude/longitude for the source location available at [www.lat-long.com](http://www.lat-long.com).** Then Select this location from the Location Information menu. You will need to convert the number for the Latitude and Longitude to fit into the CAMEO simulation. This can be done by multiplying the portion of the number presented behind the decimal point times 60. This will give the numbers that you need to put into the CAMEO simulation.

5) Complete the Set Up menu options. Select the Chemical Input first, then do the Atmospheric (you'll want the User Input option), and finally the Source input.

a) In what phase did the carbon dioxide escape?

6) Go to the Display menu and select Footprint. Use ERPG 3, 2, and 1 for the red, orange, and yellow footprints respectively.

a) Discuss the meaning of each ERPG (use the Help button).

7) We now want to transfer the footprint onto a map. Go to Aloha's Help menu (Contents) and then select Maps from the list of available topics. Copy the web location where you can obtain MARPLOT maps and paste it into a browser session. Open the file for your county. In the Filzip dialog box, select the .zip file and then the Extract menu option and place in the prescribed folder. Then rename it YOURCOUNTY.MAP. **Teacher Note: The exact files may vary slightly.**

8) Launch MARPLOT from the CAMEO Navigator display. From the View menu, select Go To View, then Map List, then Find New Map. Select the YOURCOUNTY County map and then Go to View.

9) Just below the menu bar, select the little down arrow to the left of the term Focus Pt. Then select Go to Lat/Long and enter the values for the spill location. **Teacher Note: Post prepared latitude/longitude for the source location available at [www.lat-long.com](http://www.lat-long.com).**

10) From the Sharing menu, select ALOHA and then Set Source Pt.

11) You can zoom by selecting the + magnifying glass at the left side of the display.

Analysis:

Describe the shape of the proposed evacuation zone.

What major structures are in the evacuation zone?

What are some of the possible health effects of those who do not evacuate the evacuation zone?

What factors affect how large the evacuation zone will be?

**Evaluate:**

**Collect student activities and monitor discussions.**

***Teacher Notes and Lesson Plan Regiment:  
Carbon Dioxide in the Atmosphere***

(Class period length used for the model is 45 minute sessions)

Day 1

1. Engage Segment:
  - a. Slides 1-4 on Carbon Dioxide in the Atmosphere PPT

Day 2

1. Recap Carbon Dioxide properties from day 1
2. Vocabulary discussion and students work on the Vocabulary Crossword Puzzle

Day 3

1. Explore Segment:
  - a. Lab with candles and combustion discussion (review properties of combustion)
  - b. Answer 4 questions and turn in to be corrected

Day 4

1. Discuss slides 4-10 off Carbon Dioxide in the Atmosphere PPT

Day 5

1. Recap lab experience from the day before
2. Explain Segment:
  - a. Lab with 5 beakers
  - b. Answer the 3 questions and turn in to be corrected provided
  - c. Graph the data and turn in graphs

Day 6

1. Extend Segment:
  - a. CAMEO / ALOHA / MARPLOT software simulation activity (TEACHER DEMO)
  - b. Use slides 9 and 10 on the Carbon Dioxide in the Atmosphere PPT

Day 7

1. Extend Segment:

- a. CAMEO / ALOHA / MARPLOT software simulation activity for students.

Day 8

1. Evaluation (make up day for CAMEO / ALOHA / MARPLOT software simulation activity for students.
2. Suggested NOVA film on Volcano's.

Suggested video for use during this unit  
NOVA – Volcano Under the City