West Side Science Club – Event #13 – “Carbon”

Original Presentation

Date: 18 May 2013
Time: 10 am to 12 pm
Site: West Side Science Club

Brief Description

This lesson plan describes a set of activities where students learn about the role of carbon-based molecules in providing a source of consumable energy, and the environmental consequences of burning carbon-based fuels.

Big Questions

Word of the Day: “Carbon”

(1) What is carbon? What forms can it take and in what materials is it found?

(2) Why is carbon important for energy?

(3) What are carbon and carbon dioxide’s roles in the health of our environment?

Concepts

Concepts to cover from the “Work of CCI Solar” Mind Map:

Level one (concepts): energy, reactions, fuels, first law, conversion, stewardship, climate change, sustainability

Level two (skills): science can solve big problems facing the world, developing good safety habits, human actions can impact the environment

Motivation for this Activity

The theme for this meeting was decided at the mini-retreat, with Sam and Diana present. The combustion activities are logical follow-ups to the activities from the last session on flames.

Lesson Plan

Student Objectives

- To learn that carbon is present in a variety of fossil fuels
- To trace how the carbon in fuels is converted to carbon dioxide during combustion
- To discover how increased levels of carbon dioxide can lead to global warming

Schedule/Agenda

• Review: Event #12 – "Energy and Flames"	(10 min.)
• Activity: Global Warming Demo, Part I	(20 min.)
• Demo: Butane Lighters	(20 min.)
• Activity: Carbon Dioxide Explosions	(20 min.)
• Activity: Global Warming Demo, Part II	(15 min.)
• Activity: M&M's and Carbon Sources/Sinks	(20 min.)
• Wrap-up	(10 min.)

Materials

Warm-Up Demo:

• butane lighters	(Ben)
• 20 mL butane or hexane	(Paul)
• Vials	(Paul)
• 2 porcelain pans	(Paul)
• 3 transparent cups	(Paul)
• dry ice	(Paul)
• 1 big bag of M&Ms candy, standard colors	(Ben)
• paper plates	(Ben)
• dry ice	(Paul)
• 20 microcentrifuge tubes	(Paul)
• film canisters	(Ben)
• balance?	(Paul)
• 2 L bottles	(Paul)
• Thermometers	(Paul)
• rubber septa to fit the bottles	(Paul)
• dry ice	(Paul)

Safety

- Students must wear their eye protection. We will be dealing with flames and (minor) explosions.
- Students must wear gloves, but must still be especially careful when touching the dry ice. Never touch the dry ice for longer than 2 seconds without adjusting your grip, even with gloves. The dry ice is very cold and will burn your skin.
- Do not smell the dry ice directly. That is, do not place your nose against it and inhale. The carbon dioxide will irritate your nasal passages. (Much like soda expelled through your nose.)
- All dry ice explosions of the centrifuge tubes must take place within a secondary container, like a trash can.

Review of Previous Event: Energy and Flames

- Recall the demo: Greasy food caught fire easily. (There is energy in food.)
- Recall the activity: Methanol fires can take different colors when spiked with different metal salts.

Facilitation Questions

- What unit is used to measure energy in food? (Calories. More calories = more energy)
- Lithium produced a pink flame. Copper produced a green flame. Which color has more energy? (Green. Also, blue light has photons of more energy than red light. Things closer in the rainbow to blue have more energy than other colors.)

Activity: Dry Ice Expansion

Today, we are going to explore the effect of carbon dioxide on warming an atmosphere exposed to sunlight. We are going to use dry ice.

> Does anyone know what dry ice is? (It is solid carbon dioxide. It is called dry ice because it doesn't melt, it goes directly from solid to gas as it heats up.)

We are going to use the dry ice as a source of carbon dioxide.

> What is the chemical abbreviation for carbon dioxide? (CO_2. Locate carbon and oxygen on our periodic table.)

Procedure

1. Take a small piece of dry ice—about the size of a pencil eraser. Write down its properties in your notebook (color = white, temperature = very cold, properties = “smoking”.)

   Guess how cold you think it is. (It is -78 °C, or −109 °F. That’s very, very cold.)

2. Place the piece of dry ice in a cup of water. Observe what happens and write it in your notebook (Gas bubbles come off of the solid chunk of ice.)

   What do you think those bubbles are made of? (CO_2)

   What is happening (the solid dry ice is heating up and becoming a gas, which then escapes).

   What is it called when solid ice heats up to become liquid water? (Melting. When something goes directly from solid to gas—not through a liquid phase—it is called sublimation.)

3. Wait for the CO_2 to completely disappear.

   What happened to the dry ice? Where is it now? (It is in the air.)

4. Take out two clear, empty 2 L bottles. Say that we are going to use these to simulate the Earth.

   What do you think we could add to simulate the oceans? (Water.)

5. Have two kids add 3 inches of water to each bottle.

   What can we add to introduce CO_2? (Dry ice.)

6. Have one kid put in a small chunk of dry ice, but only into one bottle.

   The other bottle we are going to leave with just regular air. It will be a control experiment to show what happens without the extra CO_2.

7. Place the thermometer caps on each bottle and have the kids place the bottles outside in the sunlight.

Warm-Up Demo: Butane Lighters

Procedure, with Facilitation Questions

1. Ben holds up a lighter and strikes it to cause a flame.

2. Pass around the lighter, which is transparent so kids can see inside. Tell them not to light it.

   What is happening? (The fuel inside the lighter is burning. The striker provides a spark to start the fire.)

   What is the fuel inside? (Lighter fluid is typically butane, $CH_3CH_2CH_2CH_3$.)

3. Draw the structure of butane on the board.

4. "Combustion" is the reaction that occurs when a fuel burns in the presence of oxygen. Fossil fuels typically produce carbon dioxide and water when they burn. Draw the reaction on the board:

   $$2\ CH_3CH_2CH_2CH_3 + 13\ O_2 \rightarrow \_\_\_\_\ CO_2 + \_\_\_\_\ H_2O$$

   (8) (10)

   How many CO_2 molecules will be produced by two butanes? (Eight. You can tell because all of the carbon should be converted to CO_2. Fill in the blank on the board.)

   How many water molecules will be produced by two butanes? (Ten. Count the hydrogens and divide by two. Fill in the blank on the board.)

5. Paul will pour a little hexane into a little porcelain pan. The kids can practice good technique in smelling the sample by wafting.

6. Paul will set fire to the hexane with a match. It is essentially the same reaction that happens with the lighter.

Activity: Dry Ice Expansion

Procedure

1. Get a new piece of dry ice that is about the size of a pencil eraser and an empty plastic microcentrifuge tube.

2. Place the dry ice in the tube, but don't close the top.

3. Close the top and quickly toss the whole tube into a garbage pail.

4. Stand three big steps back and wait for the "pop".

   What happened? (The tube exploded.)

   Why? (Because the dry ice turned into a gas and built up pressure until the tube couldn't hold the gas any longer. The plastic or cap eventually fails, resulting in the sudden release of the pressure that had slowly built up.)

5. Repeat the experiment with a marble-sized chunk of CO_2 and a film canister.

   What was the difference? (A bigger noise.)

Activity: M&M's and Carbon Sources/Sinks

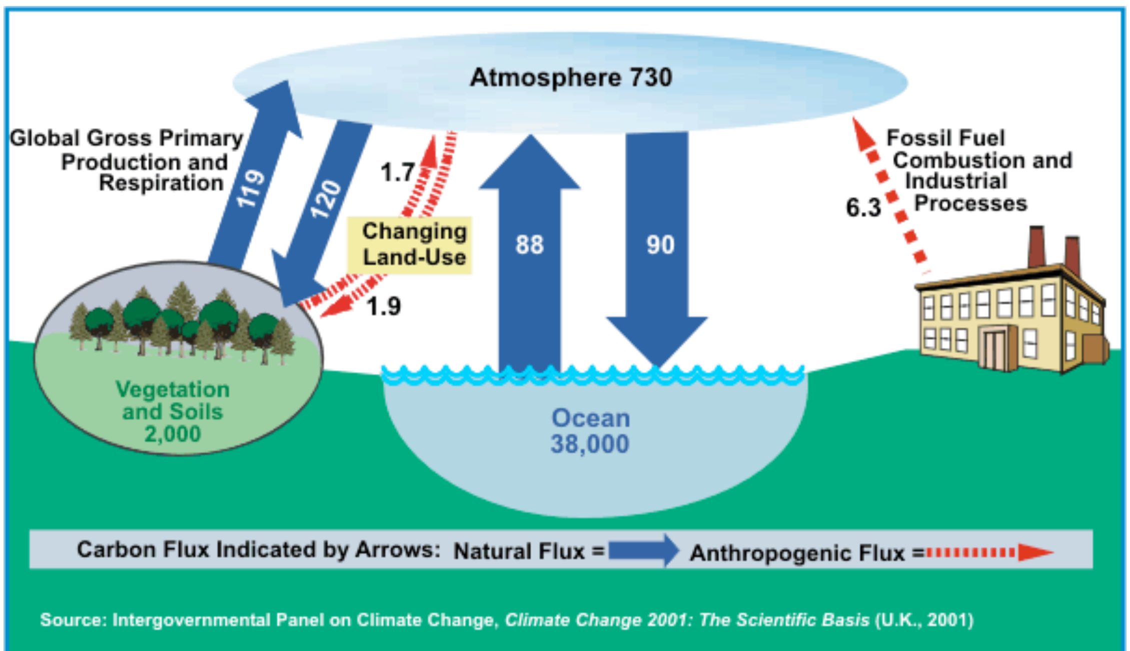
Procedure

Global Cycle Carbon Activity

Major concepts
-CO_2 is an important greenhouse gas that will heat up the air and potentially cause long term climate change
-discuss how human activity has altered CO_2 levels in the atmosphere

Go over concepts of C sources and sinks, remind kids of concepts learned from the aquarium trip- photosynthesis, a process that consumes CO_2, and respiration- a process that releases CO_2

Pose question- How would we make a diagram of this to see what's going on, to make a model? (have them draw in their notebooks)
Set up **a SIMPLIFIED 2 pools of C- land/ocean and air (can base other, more complex versions of C cycle on this diagram below)**
Draw in arrow for source of CO_2 to air, and an arrow for sink of CO_2 from air to lan/ocean (leave out CO_2 from human activities for now, and leave out land use change)
(don't worry about numbers for now)



Condition	Source	Sink	# of times exchanged	Change in Air CO2	Are the sources or sinks winning?
Natural	2	2	10	0	Neither! Both are equal
Extra human CO2 from fossil fuels	3	2	10	+10	Sources are producing more CO2 than sinks can consume
Humans reduce fossil fuel use	2	2	10	0	Nice! We got the sources under control, what about all the extra CO2 in the air?
Humans invent way to capture CO2!	2	3	10	-10	Whew!, we managed to reduced CO2 in atmosphere and return to natural conditions

Activity: model CO_2 exchange
Have students start with ~40 M&M's for their combined land/ocean C reservoir, have 2 M&M's on a plate for the "air"

1. Sources= sinks
    a. Have "source" kid place two M&M's in middle, and then have "sink" remove 2 M&M's
    b. Discuss- what's happening in the "air" (on the plate) over time?
    c. There's no CO2 building up, the sources equal the sinks
2. Sources> Sinks (we have fossil fuel burning, releasing additional CO2 into air)
    a. Place in 3 M&M's, remove 2
    b. Write down what's happening
3. Pose question to kids- How can this process be changed back?! We don't want to warm the climate too much!!
    a. Can discuss in groups the ways that people can reduce CO2 release, drive cars less, use less electricity in our buildings, get our electricity from the sun instead of burning fossil fuels
4. humans reduce CO2 sources by not burning as many fossil fuels
    a. place 2 M&M's in middle and remove 2
    b. discuss changes to CO2 in atmosphere (no CO2 building up anymore! But there's still extra CO2 in the air)
5. humans invent CO2 capture
    a. place 2 M&M's in middle, remove 3
        i. discuss and write down changes after 10 cycles

Wrap Up

- Go back and check on the 2 L bottles. (Notice that the CO_2 bottle is hotter).

Check for Understanding

- What might happen if we keep releasing a bunch of carbon dioxide in the atmosphere by burning gasoline or coal to provide our power needs?

- Can you think of sources of energy that don't rely on carbon fuels?

References

(1) Greenhouse Gas Demonstration: http://www.youtube.com/watch?v=kwtt51gvaJQ