West Side Science Club – Event #12 – "Salt and Sugar"

Original Presentation (scheduled)

Date: 4 May 2013
Time: 10 am to 12 pm
Site: West Side Science Club

Brief Description

This lesson is centered on the idea of food as a form of chemical energy, through measuring heat of combustion, and on measuring the energy of burning metal salts through measuring color of their flames.

This lab is focused on ways to measure energy. The first half looks at the easily accessible idea of energy from food and how it's measured. The second half looks at measuring more violent releases of energy in the form of colored flames. Through the session, we will review other ways that the group has measured energy, such as wavelength of light.

Big Questions

1) Why do we eat food?
2) What are calories?
3) What color is fire?

Concepts

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

Level one (concepts): energy, heat, combustion, addition of light

Level two (skills): developing good safety habits, dealing with hazardous materials, observing experiments

Motivation for this Activity

The idea of calories is common to every day experience, but where it comes from is not very clear. Similarly, fire is often experienced as being orange in color but can be any color. In both cases we are building on common experiences towards the idea of energy measurement.

Lesson Plan

Student Content Objectives

- To be able demonstrate an understanding of the idea of calories in food as a measurement of heat energy.
- To be able to demonstrate an understanding of the idea of flame color being connected to the energy of what is being combusted.

Schedule/Agenda

- Review: Event #11 – "Ocean acidification" (10 min.)
  Ask the kids where a lot of the CO_2 that's responsible for ocean acidification comes from. Focus the group on CO_2 being a byproduct of burning fuel. Transition to where the CO_2 we exhale comes from. It also comes from burning fuel – but are we really burning it?

Possible Activities

- Demonstration: How can we measure the energy in food? Combust something with high calories, such as potato chips, and something with fewer calories, such as banana chips, in order to demonstrate the difference. (10 min.)
  Important to lead with something to grab their attention –fire always works

- Discussion: Food as chemical energy - Why do we eat? (15 min.)
  Food gives us energy in the form of heat and movement – but then why don't we burst into flame?

- What are the calories on food labels telling us?

- Demonstration: combustion of a sugar and potassium chlorate mixture as a way of showing the energy released by sugar, albeit much more quickly than metabolism. (10 min.)

- Calories are one way to measure energy. What are some other ways we talked about? – reference wavelengths from our earlier light investigations and that wavelengths corresponded to colors

- Activity: What is the color of fire? Open exploration with burning metal salts in methanol solution. Students record the color of the fire from different salts, and mixture of salts. (40 min.)

- Activity: Making a rainbow of fire from the metal salts available. (15 min.)

- Wrap-up (5 min.)

Materials

General Items

- 1 bag of table sugar (Ben)
- 1 bag potato chips (Ben)
- 1 bag banana chips (Ben)
- Dehydrated fruit (Ben)

Technical items

- 1 container of potassium chlorate (Paul/Anna)
- At least 1 L of methanol (Paul/Anna)
- Lithium chloride (red flame) (Paul/Anna)
- Strontium chloride (red flame) (Paul/Anna)
- Calcium chloride (orange flame) (Paul/Anna)
- Sodium chloride (yellow flame) (Paul/Anna)
- Borax (yellow/green flame) (Paul/Anna)
- Copper sulfate (green flame) (Paul/Anna)
- Copper chloride (blue flame) (Paul/Anna)
- Potassium chloride (violet flame) (Paul/Anna)
- Magnesium sulfate (white flame) (Paul/Anna)
- Gloves (Ben)
- 18M Sulfuric acid (Paul/Anna)
- Buret (Paul/Anna)
- Ceramic crucibles (Paul/Anna)
- Goggles (Already at club)
- Pie tin (??)

Items per Table

- Watch glasses (Paul/Anna)
- Glass vials, one for each methanol/metal salt solution (Paul/Anna)
- Long Matches (??)
- Droppers (Paul/Anna)

Safety

- Students must wear their eye protection for the combustion demonstrations, as well as the flame test activities. The sugar and potassium chlorate reaction should be held in a ceramic crucible outdoors for proper ventilation.

Review of Previous Event: Ocean acidification

- Recall that we exhale carbon dioxide, and that when we burn fossil fuels we get carbon dioxide. How else could breathing be like combustion? This is a lead into the idea of metabolism as a slow form of combustion.

Warm-Up Demo: What are calories?

Procedure, with Facilitation Questions

1. Pass around bag of potato chips and banana chips.

    - Which has more calories? What does it means to have more calories?

    - How can we measure what food has more calories? (Get into the idea of calories as a measure of heat.)

    - Using a lighter ignite, some potato chips and banana chips. Compare the intensity of the flames. More heat relates to more energy, which in turn relates to more calories.

Warm-Up Demo: Combusting sugar

Procedure

1. Take equal masses of sugar and potassium chlorate, about 50 g each, and put into a ceramic crucible.

2. Place crucible in a secondary container, such as a pie tin, and place outside.

3. Using a buret, add a few mL of 18M sulfuric acid to the mixture. Make sure the students are wearing goggles and are standing away from the site. Within a few seconds the mixture will thoroughly and violently combust.

Activity: What color is fire?

Now that we have done a demonstration on the relationship between calories, combustion, and energy we're going back to the idea of color as a measure of energy by combusting various metal salts which will burn various colors:

Write on board: What color is fire? What does the color of fire tell us about the fire?

- Hand out blank data tables.
- Put a large cup full of water on each table. If you have an uncontrolled fire, douse it with water. Water is great at killing methanol fires. You must be vigilant because (pure) methanol fires are colorless.
- As a demonstration, fill a watch glass with ~5 mL of methanol and ignite it. What color is the fire? It is practically invisible. Also note that it produces no smoke. Not all fire makes smoke or color!
- Now, we are going to have you set fire to the same liquid (methanol) with various salts. Do you remember what it's called when a solid disappears and goes inside of a liquid (making a solution or dissolving).
- Distribute small vials that contain different salts.
- The kids should use pipettes or squirt bottles to fill the vials almost to the brim with methanol. (Warning: do not drink the methanol…it can cause blindness if ingested). At this point, cap the vials and shake them to dissolve the salt. Do not worry if there is still solid remaining after three minutes of vigorous shaking…it's good enough!
- Uncap each vial, then fill it to the very brim with a few more drops of methanol. (Do not contaminate the vials with other salts, and don't contaminate the stock solution of methanol!)
- Place the vial on a placemat, then hold a match to the opening of the vial to ignite the methanol.
- Observe the color of the flame and record it on the chart in your notebook.
- When satisfied, extinguish the flame at the tip of the vial by gently blowing it out. Do not blow the vial over. If you blow the vial over, douse it immediately with water, then wipe up the water.
- Which flames correspond to more energy? (blue > green > yellow > orange > red)
- Now, what happens if you mix the salts? (You should get additive mixing of light, e.g., red + green = yellow)
- Using pipettes, the students can mix two solutions on a clean watch glass. Ignite the sample with a match and observe the color produced.

- Student mentors help out with students' running their flame tests.

Facilitation/Concept Questions

- Mentors should be supportive and talk students through their ideas without giving away the answers
- Do different color flames mix in a predictable fashion? E.g. does red and blue fire combine to make purple flame?
- How does the color of the flame relate to the energy released by the burning of the metal salts.

Wrap Up

- Given their lab notes students will make a prediction as to what salt solutions to use in making a fire rainbow. Each table will set up their flame series and ignite it.

What is similar about applying acid and applying a flame to a substance?
Give an example of how people use sparks or a flame to use up a substance's energy.
Give an example of how animals use acid to use up a substance's energy.

Check for Understanding

- As color gets closer to red on the rainbow what happens to the amount of energy associated with the light?
- How can we measure the energy in food?

References

(1) Metal salt flame tests: http://chemistry.about.com/od/funfireprojects/a/coloredfire.htm

(2) Sugar and potassium chlorate reaction:
http://www.angelo.edu/faculty/kboudrea/demos/instant_fire/instant_fire.htm