HEAT AND CALORIMETRY

In this lab you will measure the latent heat of fusion of ice as it melts. Using your value for the latent heat, you will then determine how much thermal energy is released when a peanut burns.

Background

Calorimetry is a technique that can be used to determine the specific heats and latent heats of substances. To measure the specific heat: (1) Heat the substance to a known temperature; (2) Place it in a container of known mass and temperature that holds water of known mass and temperature; and (3) Measure the final temperature after thermal equilibrium is reached. Conservation of energy implies that the heat that leaves the substance must equal the heat that enters the water and the container:

$$-Q_{lost} = Q_{gained}.$$

The heat gained is given by: $Q_{\text{gained}} = mc\Delta T$, where m is the mass, c is the specific heat, and $\Delta T = T_f - T_i$ is the change in temperature of the substance.

In this example: $Q_{\text{gained}} = m_{\text{water}}c_{\text{water}}\Delta T_{\text{water}} + m_{\text{container}}c_{\text{container}}\Delta T_{\text{container}}$

A similar equation can be written for the heat lost by the substance:

$$Q_{\text{lost}} = m_{\text{substance}}c_{\text{substance}}\Delta T_{\text{substance}}$$

In the above equations the addition (or loss) of heat lead to a temperature change for a substance. Heat can also be removed or added to produce a phase change, such as when ice melts or water freezes. A phase change occurs at constant temperature. The relationship between heat and latent heat is:

$$Q = mL,$$

where m is the mass and L is the latent heat of the substance.

This equation determines the heat required to produce a phase change in a substance of mass m. The latent heat is the same for melting and for freezing and is called the "latent heat of fusion", L_f. There is a different value for the latent heat of vaporization and condensation, and it is called the "latent heat of vaporization", L_v. Latent heat is given in units of either $\frac{J}{kg}$ or $\frac{cal}{g}$.

Latent heat of fusion for ice.

Materials and equipment: calorimeter, ice, water, temperature probe, scale.

Here's What You Do:

- Find the mass of the inner calorimeter cup.
- Using a graduated cylinder or beaker, carefully measure 150 ml of room temperature water and pour it into the cup. Mass the water and the cup and place the inner cup inside the outer cup of the calorimeter.
- Use Logger Pro to measure the temperature of the water to the nearest 0.1 degree Celsius after it has stabilized. Leave the temperature probe in the cup.
- Obtain several ice cubes which have partially melted, so that their temperature is 0 degrees Celsius. Dry the ice cubes with a towel to remove any excess liquid, then add them to the cup. Gently stir the ice and water with the temperature probe. Observe the temperature as it decreases. When the temperature becomes constant, record the final temperature to the nearest 0. 1 degree Celsius.
- Remove the remaining ice, shaking as much water as possible back into the cup. Again measure and record the mass of the water and the cup.

Questions

1. How much ice was melted? Show your calculation.
2. Find the heat lost in the system, $Q_{lost.}$, considering that the 150 ml of water cooled from room temperature to the final temperature and the inner aluminum calorimeter cup cooled from room temperature to the final temperature. Show your calculation.
3. Using your value for Q_{lost} and the equation for the heat gained by the ice from melting, solve for the latent heat of fusion, L_f, for ice. Show your calculation. Compare your value for L_f to the accepted value (3.33×10^5 J/Kg) by finding the percent error.

4. The U.S. penny is now made of copper-coated zinc. Can a colorimetric experiment be devised to test for the metal content in a collection of pennies? If so, describe the procedure.

Chemical to Thermal Energy

You know that the energy that keeps your brain and body going comes from the food you eat. Your digestive system and the cells in your body break down the food and gradually oxidize the resulting molecules to release energy that your cells can use and store.

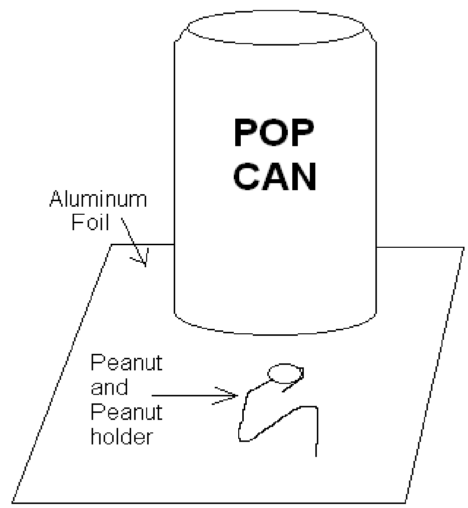
Have you ever wondered how nutritionists know how many Calories a certain food contains? In this activity you'll learn a method for measuring how much chemical energy is available in different types of food. You will build your own calorimeter to capture the energy released by burning a small food item, like a nut or a piece of popcorn. This activity gives a new meaning to the phrase "burning calories."

Objective

The goal of this experiment is to determine the amount of chemical energy stored in food by burning it and capturing the heat given off in a homemade calorimeter.

To measure the amount of thermal energy in a peanut you will measure the amount of ice the peanut can melt when it burns.

Here's what you do:



- Lay the aluminum on the table top to protect the surface. Turn up the edges to make a shallow tray. If the peanut falls off the stand, the edges should keep it from falling on the floor.
- Fill the "POP" can about 1/4 full of ice.
- Set the peanut on the paper clip stand as shown.
- Light the peanut by holding the match directly below the peanut. It might take a couple of matches to get the peanut burning.
- Another person should pour off any excess water that has collected while someone is trying to light the peanut. There should be as little water in the can as possible when the peanut starts to burn.
- As soon as the peanut starts to burn by itself, the match should be removed and the "POP" can held about 5 centimeters (2 in.) above the peanut.
- Hold the can above the flame and gently swirl as long as the peanut continues to burn (if your peanut goes out prematurely you will have to relight it).
- When the peanut has burned as completely as it is going to, measure the volume of water (1 ml = 1 g) that was melted by the flame.

Questions

1. Calculate the thermal energy required to melt your water.
2. Find the chemical energy lost by the peanut in food Calories (capital C – "big calories") which are actually Kilocalories (1000 calories = 1 Calorie).
3. There are about 40 average peanuts in a one ounce serving. How many calories would there be in an average serving? Write this value on the board.
4. How does your value of calories per serving size compare to the class average? How does the class average compare to the label?
5. Why do you think the class average is different from the label?

6. What improvements do you think real calorimeters have over our homemade version?

7. Why was it suggested to have plenty of ice in the pop can that you held over your peanut while it burned? What change, if any, to your procedures would you have had to make if all of the ice melted in your experiment?