

INTRODUCTION:

Calorimetry is a technique that is used to determine the heat involved in a chemical reaction. When determining the heat of combustion of a substance or the caloric value of foods, the measurements are often made using a *bomb calorimeter*. In this device, the weighed sample is placed in a heavy steel container called a *bomb* and the atmosphere of the bomb is filled with pure oxygen. The bomb is then placed in a well insulated container called a *calorimeter* which has been filled with a measured amount of water. The sample, in the pure oxygen atmosphere, is ignited by an electric spark and the heat generated by the burning sample warms the bomb and the surrounding water. At equilibrium, both the bomb and the water will be at the same temperature.

Using the law of conservation of energy:

$$\text{Heat evolved by the reaction} = \text{Heat absorbed by the water} + \text{Heat absorbed by the bomb}$$

or, in equation form:

$$q_{\text{reaction}} = -(q_{\text{water}} + q_{\text{bomb}}) \quad (\text{where } q \text{ is the symbol for heat})$$

The q_{reaction} has a negative value because the combustion reaction is *exothermic* (i.e., it releases energy to the surroundings). The q_{water} and the q_{bomb} are calculated from the temperature change of the water and the bomb and the specific heat of the water and the bomb. The total gives the heat of combustion of the sample that was used.

In this experiment, the energy of a cheeto will be determined using a simplified set-up. The cheeto will be burned in air, instead of pure oxygen. Instead of a heavy metal bomb, a metal can, such as an aluminum soft drink can, a small juice or soup can is used. To eliminate the determination of the specific heat of the metal can (the heated needed to heat the metal that composes the can), the experimental conditions are modified to maintain a constant temperature of the can by filling it with a large quantity of ice. This will maintain a temperature of 0°C, as long as all the ice does not melt. The heat evolved by the burning cheeto will melt some of the ice and the amount of liquid water formed will be measured to give the heat of combustion of the sample.

After determining the energy of a cheeto, the procedure will be repeated using other snack foods.

EXPERIMENTAL PROCEDURE:

- 1) Set up the apparatus as shown in *Figure 1*. Use a large adjustable clamp to hold the metal can. Place a metal stand for holding the cheeto on the base of the ring stand. Loosen the clamp and move the metal can off to the side of the apparatus.
- 2) Select a cheeto and weigh it. **Record its mass.**
- 3) Add ice to the Beaker so it is at least half-filled.
- 4) Place the cheeto on the stand and light it using a match or a burner. Move the can over the burning cheeto and position it so that the top of the flame just touches the bottom of the can. Allow the cheeto to burn completely. If the flame goes out and the cheeto is not completely burned, relight the cheeto. Remember to move the can away from over the cheeto when relighting it.
- 5) After the cheeto, or other food material, is burned, some charcoal remains. Carefully transfer the remaining material to a *preweighed* weighing dish, and weigh it. **Record the mass of the remaining material.** The mass of cheeto, or food, burned is equal to the initial mass of the cheeto or other food, minus the mass of the remaining material.
- 6) After the cheeto has burned out, using the clamp holding the beaker as a handle, carefully pour the liquid water (but no ice) from the beaker into the graduated cylinder. **Record the volume of the water**
- 7) Repeat the procedure with another cheeto (or corn nut).

CALCULATIONS:

In this experiment, heat is measured in calories. One calorie is the quantity of heat needed to raise the temperature of one gram of water by 1°C. Due to the excess of ice in the metal can, the temperature of the system should remain constant at 0°C, thus we are melting ice into liquid water at a constant temperature. The heat needed to melt one g of ice to water at 0°C is known as the *heat of fusion* and has a value of 80 cal/g for water.

The density of water is 1.0 g/cm³, so the volume of water in mL will be equal to the mass of the water in g.

$$1 \text{ mL H}_2\text{O} = 1 \text{ g H}_2\text{O}$$

The heat produced by the burning cheeto is calculated by the equation:

$$q_{\text{cheeto}} = m_{\text{water}} \times 80 \text{ cal/g}$$

where: q_{cheeto} = heat produced by the cheeto in calories
 m_{water} = mass of the water in g (this is equal to the volume of the melted ice in mL)
80 cal/g = the heat of fusion of ice (the heat needed to melt one gram of ice)

The heat, in calories, generated by a one gram sample of the cheeto is calculated by the equation:

$$q = \frac{q_{\text{cheeto}}}{m_{\text{cheeto}}}$$

where: q = heat generated per gram of sample in calories
 q_{cheeto} = heat produced by the burning cheeto in calories
 m_{cheeto} = mass of the cheeto that burned in grams

Calculate the *nutritional calories* or *kilocalories* available from the cheeto you used. To calculate kilocalories, divide the heat generated by 1 gram of sample by 1000.

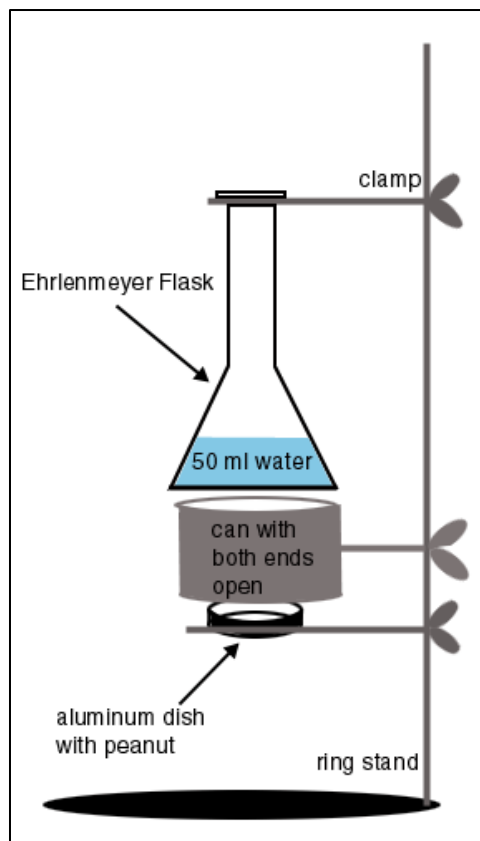
$$\text{kilocalories} = \frac{q}{1000 \text{ cal/kcal}}$$

where q = heat generated per gram of sample in calories

To calculate "Calories" per gram (from label)

$$\text{"Calories" per gram} = \frac{\text{"Calories" per serving size}}{\text{Serving size in g}}$$

FIGURE 1.



Energy of a cheeto or corn nut ← Circle which one you had

	Trial 1	Trial 2
Mass of cheeto		
Mass of remaining material		
Mass of cheeto that burned		
Volume of liquid water		
Mass of liquid water (see calculations section)		
Heat produced by cheeto = $q_{\text{cheeto}} = m_{\text{water}} \times 80 \text{ cal/g}$		
Heat produced by 1 gram of cheeto $q = \frac{q_{\text{cheeto}}}{m_{\text{cheeto}}}$		
Kilocalories of heat from 1 gram of cheeto $\text{kilocalories} = \frac{q}{1000 \text{ cal/kcal}}$		
Serving size (from label)		
"Calories" per serving size (from label)		
"Calories" per gram (from label)		

Show calculations for one of your trials here:

QUESTIONS:

1) Why is it necessary to maintain a large excess of ice in the metal can?

2) Describe 2-3 errors that you encountered in this procedure and how do they affect the results (i.e., a large effect or a small effect)?

3) How does your value for the caloric energy of a cheeto (or other food) compare to the label information? Explain.

4) What should you have learned regarding thermochemistry from this experiment? Describe 4 different aspects clearly.