ENERGY OF A PEANUT
AN EXPERIMENT IN CALORIMETRY

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:

Heat evolved by the reaction = Heat absorbed by the water + Heat absorbed by the bomb

or, in equation form:

$$q_{reaction} = -(q_{water} + q_{bomb})$$ (where *q* 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 peanut, or another kind of nut, will be determined using a simplified set-up. The peanut 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. 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 0ºC, as long as all the ice does not melt. The heat evolved by the burning peanut 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 peanut, (or other type of nut) the procedure will be repeated using other snack foods.

1. MATERIALS NEEDED:

       a metal can (a small juice can, soup can, or soft drink can) with the top removed
       heavy wire stand to hold the peanut. This can be constructed from an extra large
       paper clip (see photo on right)
       150ºC thermometer
       graduated cylinder, 100-mL or 250-mL
       tongs or forceps
       funnel
       peanuts or other nuts such as almonds, cashews, pecans, walnuts, etc.
       ice
       snack foods such as cheese curls, potato chips, etc...

2. SAFETY PRECAUTIONS:

       Wear safety goggles or glasses at all times in the laboratory.

CAUTION – HEALTH HAZARD: This procedure involves burning nuts. If you are allergic to nuts, or have any severe food allergies, inform your instructor immediately so that you may be excused from this experiment. Do not stay in the laboratory.
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There are no safety hazards with any of the materials used in this experiment.

The metal stand holding the sample will get hot during the reaction. Handle it using tongs or forceps.

Do not eat any of the foods used in this experiment. It is assumed that they may be contaminated with laboratory chemicals.

3. DISPOSAL:

There are no disposal problems with materials in this experiment. Burnt peanuts, or snack food, can be disposed of in the trash. Ice and water should be placed in sink.

4. EXPERIMENTAL PROCEDURE:

Obtain a metal can. If necessary, wipe any carbon deposits off the bottom of the can using a paper towel.

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 peanut on the base of the ring stand. Loosen the clamp and move the metal can off to the side of the apparatus.

Select a peanut (or other nut), weigh it, and record its mass.

Add ice to the can so it is at least half-filled.

Place the peanut (or other nut used) on the stand and light it using a match or a burner. Move the can over the burning peanut and position it so that the top of the flame just touches the bottom of the can. Allow the peanut to burn completely. If the flame goes out and the peanut is not completely burned, relight the peanut. Remember to move the can away from over the peanut when relighting it.
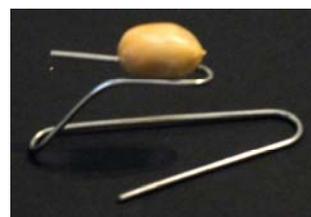
After the nut, or other food material, is burned, some charcoal remains. Carefully transfer the remaining material to a *preweighed* piece of weighing paper, or a weighing dish, and weigh it. Determine the mass of the remaining material. The mass of peanut, or food, burned is equal to the initial mass of the peanut, or other food, minus the mass of the remaining material.

After the peanut has burned out, using the clamp holding the can as a handle, carefully pour the liquid water (but no ice) from the can into the graduated cylinder. Placing a funnel on top of the graduated cylinder will prevent any solid ice from falling into the cylinder. Determine the volume of the water and record it in your notebook. If desired, you may also measure and record the temperature of the water.

Repeat the procedure with another peanut (or the same kind of nut previously used).

How do your results compare with the caloric values on the label of the food container?

Select different kind of nut than you used for the first two trials, or a sample of another food material (such as corn or cheese curls, potato chips, or tortilla chips) supplied by your instructor. Repeat the procedure twice more using the food sample.
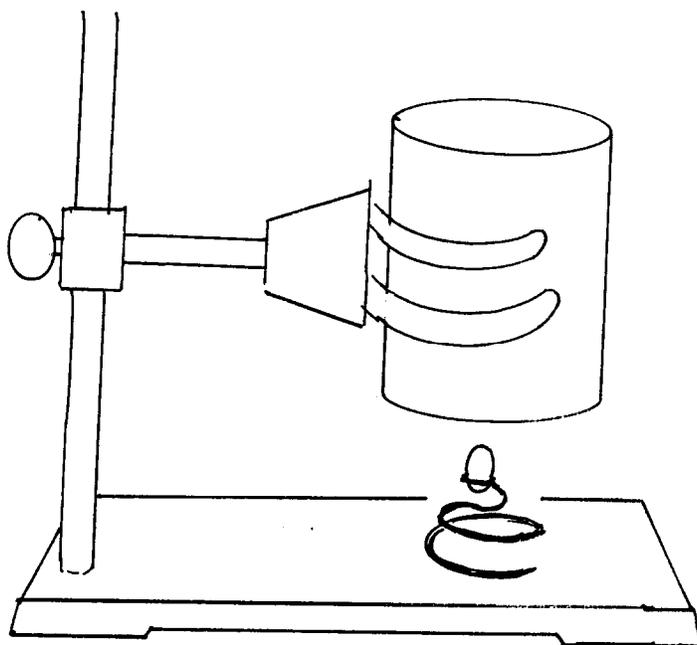
Figure 1. Apparatus for determination of the energy of a peanut

5. 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 1ºC. Due to the excess of ice in the metal can, the temperature of the system should remain constant at 0ºC, thus we are melting ice into liquid water at a constant temperature. The heat needed to melt one g of ice to water at 0ºC 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/cm^3, so it is assumed that the volume of water in mL will be equal to the mass of the water in g.

$$1 \text{ mL } H_2O \ = \ 1 \text{ g } H_2O$$

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

$$q_{peanut} \ = \ m_{water} \text{ x } 80 \text{ cal/g}$$

where: q_{peanut} = heat produced by the peanut 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 peanut is calculated by the equation:

$$q \ = \ \frac{q_{peanut}}{m_{peanut}}$$

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

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

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

where   q = heat generated per gram of sample in calories

To calculate "Calories" per gram (from label)

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

ENERGY OF A PEANUT
DATA AND RESULTS

Name_____   Course/Section_____

Partner's Name (If applicable) _____   Date _____

Procedure 1. Energy of a Peanut

	Trial 1	Trial 2

Mass of peanut or _____
(type of nut used)   _____ g   _____ g

Mass of remaining material after burning   _____ g   _____ g

Mass of peanut that burned   _____ g   _____ g

Volume of liquid water   _____ mL   _____ mL

Mass of liquid water (see calculations section)   _____ g   _____ g

Heat produced by peanut or _____
(type of nut used)   _____ cal   _____ cal

Heat produced by 1 gram of peanut   _____ cal/g   _____ cal/g

Kilocalories of heat from 1 gram of peanut   _____ kcal/g   _____ kcal/g

Serving size (from label)   _____ g

"Calories" per serving size (from label)   _____ "cal"

"Calories" per gram (from label)   _____ cal/g

"Calories" from fat (from label)   _____ "cal"

Show one set of your calculations in the space below:

Procedure 2. Energy of a _____
<center>(food product used)</center>

	Trial 1	Trial 2
Mass of _____	_____ g	_____ g
Volume of liquid water	_____ mL	_____ mL
Mass of liquid water	_____ g	_____ g
Mass of remaining material after burning	_____ g	_____ g
Mass of _____ that burned	_____ g	_____ g
Heat produced by _____	_____ cal	_____ cal
Heat produced by 1 gram of _____	_____ cal/g	_____ cal/g
Kilocalories of heat from 1 gram of _____	_____ kcal/g	_____ kcal/g
Serving size (from label)	_____ g	
"Calories" per serving size (from label)	_____ "cal"	
"Calories" per gram (from label)	_____ cal/g	
"Calories" from fat (from label)	_____ "cal"	

QUESTIONS:

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

2. What errors do you encounter 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 peanut (or other food) compare to the label information?

4. Calculate the "calories per gram of fat" (from the label information) for the foods you tested. How do these values compare with your experimental values?