Name: ____ Date: __________________ Period: _____

Counting Calories: Burn a Cheeto

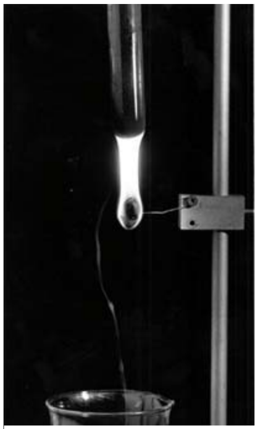

Figure 1: Burn a peanut and use its heat to boil water.

Introduction: Humans and other heterotrophs digest food to be able to produce usable chemical energy. The process of creating this energy from food (specifically sugar) is known as *cellular respiration*. A summary equation is often used to represent this process:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

This equation is read, “One molecule of glucose is burned in the presence of six oxygen molecules to yield six molecules of carbon dioxide and six molecules of water”. This equation is classified as a “combustion reaction”. It is practically identical to the process of burning any organic molecule (e.g., wood, starch, alcohol, wax or lipid).

The chemistry of burning any organic molecule with fire and digesting your dinner is the same.

All food particles have a specific amount of stored energy. Energy stored in food can be quantified in terms of Calories. The specific amount of Calories can be determined by burning the food under a set of controlled conditions. A careful measurement of thermal energy released is required. This procedure is known as calorimetry and the measuring device is called a calorimeter. In this lab we will be calculating the Calories, or amount of energy, stored in various food items.

Lab Overview:

A peanut will burn producing an impressive amount of flame for a long time. The flame can be used to boil away water and count the calories contained in the peanut.

One peanut may release as much as 1880 calories! Those of you who know about the calorie content of food may be shocked at this number. However food calories and physicist calories are different. One food Calorie contains 1,000 physicist calories. Notice how food calories are written with a capital C to indicate that they are different from physicist calories. So 1.88 food Calories were captured from the burning peanut.

Pre-Lab Questions:

1. Define calorie.
2. Define Calorie.
3. What is calorimetry and who would be interested in performing it?
4. What is a calorimeter and why would it contain water?
5. Rank the following in terms of the energy they contain: fats, carbohydrates, proteins.
6. At what temperature does water boil? ______ ^{o}F ______ ^{o}C
7. What is the mass of 30mL of water? ______ 60mL of water? ______ 1000mL of water? ______ Explain!

Materials:

___ 1. Food items (e.g., potato chips, Cheetos, and croutons)
___ 2. 70mL test tube
___ 3. ring stand with test tube clamp
___ 4. graduated cylinder
___ 5. 30 mL tap water
___ 6. large paper clips
___ 7. ceramic crucible to collect ash or to catch falling, burning food items
___ 8. lighter
___ 9. balance with weighing boat
___ 10. Thermometer
___ 11. Marble boiling chips
___ 12. Tongs

Assembly:

1. Watch your teacher's demonstration to bend the large paper clip as shown to make a peanut holder. Use tape to mount the paper clip in the center of the evaporating dish. The evaporating dish is necessary because the burning peanut may fall off the holder or drip flaming fat drops.
2. Place 30 mL of water into the test tube.
3. Mount the test tube in the "holder" over the paper clip.
4. Tip the test tube at a slight angle, 30 degrees or so. This arrangement will allow the water to boil without forcing liquid water out of the tube.

Precautions and Tips:

___ 1. Find the mass of the whole peanut/chip/crouton in grams before you burn it. Record this information in your data table.
___ 2. Mount the peanut on the bent-paper clip peanut holder. Tape it securely, ensuring it won't fall over.
___ 3. Make sure the peanut is a few centimeters under the test tube of water.
___ 4. Make sure your hair and clothing is out of the way and will not be close to the burning peanut or the match.
___ 5. Light the peanut, just hold the match under it, the peanut will catch on fire.
___ 6. Notice the long burning flame. Notice that the water in the test tube begins to boil violently.
___ 7. Let the peanut burn out and the test tube cool for 5 minutes or so.
___ 8. Measure the amount of water left in the test tube and compute the volume lost to evaporation. Convert this to mass of water that boiled away.
___ 9. Complete the data table to help you to calculate the caloric content of your food items.

What's Going On?

The peanut burned in the presence of atmospheric oxygen.

Heat flowed from that burning peanut as combustion converted the hidden chemical energy stored in the nut into the easily measured energy of heat flow. When you eat a peanut, your body does the same sort of thing: it converts the energy stored in the peanut into the energy it needs to keep running.

If the burning peanut raised the temperature of ten milliliters or ten grams of water from tap water temperature, 20 °C, to the boiling point, 100 °C then it boiled away 2 grams of water. This information can be used to calculate the energy released by the peanut 1880 calories. (See the data section that follows to do the calculations for your food items.)

The metric unit of energy is not the calorie, but rather, it is the Joule.

One food Calorie (or 1000 "little c" calories) is equal to 4200 Joules. So we captured a little less than 8000 Joules from our burning peanut.

Data Table:

	Food #1: ____________	Food #2: ____________	Food #3: ____________
M_i (g)			
M_f (g)			
ΔM (g)			
T_i (^oC)			
T_f(^oC)			
ΔT (^oC)			
V_i (mL)			
V_f (mL)			
ΔV (mL)			
Q (cal) (heat required to raise the water temp to boiling)			
Q (cal) (heat required to evaporate the water)			
Total Calories in food item:			

M_i = Initial mass of food
M_f = Final mass of food
ΔM = Change in mass of food (M_i-M_f)

T_i = Initial temperature of water
T_f = Final temperature of water
ΔT = Change in temp. of water (T_f-T_i)

V_i = Initial volume of water
V_f = Final volume of water
ΔV = Change in volume of water (V_i-V_f)

To Do the Math, Follow this Example:

To raise the temperature of 30 grams of water from 20 °C to 100 °C it takes:

$$Q = (M_i)(c)(\Delta T)$$

Where Q is the heat flow in calories,
M_i is the initial mass of the water in grams (same as the volume in mL – from your data table above),
c is the specific heat of water which = 1 degree/calorie/gram
and ΔT is the temperature change in °C.

$$Q = (10)(1)(80) = \underline{800 \text{ calories}}$$

This is the energy required to get the water to 100°C, the temperature at which water BOILS. Now we must add the energy required to VAPORIZES the heated water into steam. Let's say there are 28 mL of water left after the experiment. That means 2 mL of water were boiled off, and the calculations would be as shown below. If there are still 30 mL of water left after your experiment, you do not need to do this portion of the calculation for that food.

To boil away 2 grams of water

$$Q = (L)(\Delta V)$$

Where L is the latent heat of vaporization of water, L= 540 calories/gram and
ΔV is the change in volume of water (from your data table above)

$$Q = (540)(2) = \underline{1080 \text{ calories}}$$

Therefore: >>The total energy needed is the sum of these two Q = 800 + 1080 = 1880 calories!<<

Questions for review and understanding:

1. Food scientists use a device known as a bomb calorimeter to measure the calorie content of foods. The bomb calorimeter does a better job of catching all of the energy released by the burning peanut. Experiments with a bomb calorimeter capture 6.3 Calories from a peanut the size of the one used as an example in this experiment, 1.0 gram. So this open air experiment captured less than a third of the calories released by the burning peanut. Can you find ways to improve this experiment so that more of the heat flow from my peanut is captured?

2. What would happen were you to repeat this experiment at a high elevation (like in Denver where the average elevation is 5183 feet above sea level)?

3. How many Calories in 5 grams of carbohydrate? ______

4. How many Calories in 5 grams of protein? ______

5. How many Calories in 5 grams of fat? ______

6. You buy a bag of shrimp flavored potato chips from an Asian market. According to the nutrition label, each serving (about 10 chips) contains 140 kilocalories. What does this mean? Should you eat these chips?

7. Which food item was most caloric? ____________ Provide a rationale for this.

8. Why did you collect mass data for the food items if their masses were not involved in any of the calculations?