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**Soda Can Calorimeter Lab**

Have you ever noticed the nutrition label located on the packaging of the food you buy? One of the first things listed on the label are the calories per serving. How is the calorie content of food determined? This activity will introduce the concept of calorimetry and investigate the caloric content of snack foods.

**Background**

The law of conservation of energy states that energy cannot be created or destroyed, only converted from one form to another. This fundamental law was used by scientists to derive new laws in the field of *thermodynamics—*the study of heat energy, temperature, and heat transfer. The *First Law of Thermodynamics* states that the heat energy lost by one body is gained by another body. Heat is the energy that is transferred between objects when there is a difference in temperature. Objects contain heat as a result of the small, rapid motion (vibrations, rotational motion, electron spin, etc.) that all atoms experience. The temperature of an object is an indirect measurement of its heat. Particles in a hot object exhibit more rapid motion than particles in a colder object. When a hot and cold object are placed in contact with one another, the faster moving particles in the hot object will begin to bump into the slower moving particles in the colder object making them move faster (vice versa, the faster particles will then move slower). Eventually, the two objects will reach the same equilibrium temperature—the initially cold object will now be warmer, and the initially hot object will now be cooler. This principle is the basis for *calorimetry,* or the measurement of heat transfer.

In the 1770s, Joseph Black (1728–1799) was one of the first scientists to conduct calorimetry experiments with different materials. He discovered that not all materials are equal when it comes to heat transfer. He concluded that different materials have their own unique ability to retain heat energy. Some materials, like water, can gain a large amount of heat energy without a significant change in temperature, while other materials, such as metals, will have a more dramatic temperature change for the same amount of heat energy gained. This property is based mainly on the structure of the material, the size of the atoms and molecules, and the interactions between them. This is known as the *specific heat* of the substance. The specific heat is defined as the heat energy required to raise one gram of a substance by one degree Celsius. With the specific heat of a substance know, the amount of heat energy gained or lost by a substance can then be calculated if the temperature change is measured.

In this experiment, the specific heat of water and its change in temperature will be used to determine the caloric content of really a kilocalorie, or 1000 calories (lowercase c). During calorimetry, food burns and its stored energy is quickly converted into heat energy and products of combustion (carbon dioxide and water). The heat energy that is released is then transferred into the water above it in the calorimeter. The temperature change in the water is then measured and used to calculate the amount of heat energy released from the burning food. The heat energy is calculated using Equation 1.

Equation 1: q=mcΔT

q = heat energy  m = mass of the water   c=specific heat capacity

ΔT = change in water temperature, Tfinal – Tinitial (“Δ” is the Greek letter Delta which means “change in”)

**Materials**

Food holder, 1 piece of each individual snack food, pop can butane lighter. ringstand with metal clamp, scale, 50 mL graduated cylinder, glass stirring rod, thermometer, water

**Procedure**

1. Place a food sample on the food holder. Measure and record the combined mass of the food holder and sample. Place the food holder on the base of a support stand.
2. Using a graduated cylinder, measure and add 50.0 mL of water to an empty, clean soda can. This value in mL is equal to the amount of grams of water.
3. Bend the tab on the soda can and slide a glass stirring rod through the hole. Rest the glass stirring rod on the metal ring. Suspend can so that it is about 1 inch above the food holder.
4. Insert a thermometer into the can. Measure and record the initial temperature of the water.
5. Light the food sample using the butane lighter and center it under the can. Allow the water to be heated until the food stops burning. Record the maximum (final) temperature of the water in the can.
6. Measure and record the final mass of the food holder and sample

 7. Clean off the bottom of the can and remove any food residue from the food holder with a paper towel.

8. Repeat steps 1-7 for the other two food samples.

**Data :**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Food Sample** | **Initial Mass**  | **Final Mass**  | **Initial Temperature (Ti of water)** | **Final Temperature (Tf of water)** |
| Cheese Puff  |  |  |  |  |
| Marshmallow |  |  |  |  |
| Tortilla Chip |  |  |  |  |

**Analysis and Calculations**

1. Determine the change in temperature of the water for each food sample by subtracting the initial water temperature from the final water temperature.

Δ*T = Tfinal – Tinital*

Cheese Puff:

Marshmallow:

Tortilla Chip:

2. Calculate the heat gained by the water for each food sample using the following equation. Make sure you are using the mass, specific heat, and change in temperature of water:

q=mcΔT

Cheese Puff:

Marshmallow:

Tortilla Chip:

3. Convert the amount of Joules found in the previous step to kilocalories using the following equalities:

4.184 joule = 1 calories 1000 calories = 1 kilocalorie

Cheese Puff:

Marshmallow:

Tortilla Chip:

4. Determine how much of each food sample burned by subtracting the final mass of the food from the initial mass.

Cheese Puff:

Marshmallow:

Tortilla Chip:

5.Calculate the energy content per gram of each food sample. Do this by dividing the amount of kcal for each food sample by the change in mass of each food sample.

Cheese Puff:

Marshmallow:

Tortilla Chip:

6. How many grams of each food would I need to eat to consume 200 Calories (Calories = kcal)? Show calculations below.

Cheese Puff:

Marshmallow:

Tortilla Chip:

7. Calculate how many Joules of energy I would receive from 5 grams of each food:

Cheese Puff:

Marshmallow:

Tortilla Chip: