

Name: _____ Date: _____

Heat Transfer: Counting Calories Activity – Wait, What Just Happened? Worksheet



Part I: How Did You Do That?

1. What do you think caused the water temperature to drop so much?

2. Why didn't the water in the beaker freeze while the water outside the beaker did?

3. Can you think of a good way to measure the amount of energy absorbed in this reaction? List your ideas below.

Part II: Background

A calorimeter is a fairly simple device. All that is required is a chamber in which to house an energy generating reaction, and some substance with a known heat capacity to capture the heat generated. There are many different types of calorimeters. For example, in large particle accelerators, physicists use specialized calorimeters to detect the quantized energy given off by the presence of rare subatomic particles. Food chemists use bomb calorimeters to measure the energy content of food. A bomb calorimeter is a type of constant volume calorimeter which is divided into two parts. Imagine a cylinder within a cylinder. The smaller cylinder, which is made of a highly conductive material, contains an excess of oxygen, an electrical igniter, and the food in question. The larger cylinder surrounding it contains water and a thermometer and is well insulated.

For this activity, we will use water because it is readily available and its properties well understood. Depending on the type of calorimeter used, this can be housed in the same chamber as the reaction (such as dissolving one substance in another) or in a different chamber (such as for a combustion reaction). Heat transfer to the surrounding structure of the calorimeter should be minimal. The heat should instead go into the measuring substance to raise its temperature. Where do you think the calorimeter would lose heat? For simplicity's sake, we will assume that the moving water is heated uniformly when stirred effectively.

A much simpler calorimeter is a coffee cup calorimeter. Though there are variations, this works on the same principle as other calorimeters. In this case, a cup holds the *reaction of interest*, and a thermometer measures the temperature change. In this activity, the dissolution of potassium chloride salt (KCl) in water is the reaction of interest. We want to maximize the amount of energy going into the water, so the cup should be as insulating as possible. Multiple layers might even be used (that is, a cup nested inside of another cup). We also want to minimize losses elsewhere. Where else might we lose heat? The mechanism of transport of heat in this device includes both conduction through the barrier and convection of the water. In order for our assumption of uniform temperature to be valid, it must be stirred, no matter the design. Why does this make a difference? Well, stirring the water helps ensure that the hot and cold water in the cup are well mixed. This assures us that the heat will be evenly distributed and that we will get an accurate temperature reading.

Calculations

In order to figure out how much energy is transferred, we first need to know some important equations. First, the heat (Q) is related to the change in temperature (T) by the heat capacity (C_p) for a given number of moles (n). The equation we get is as follows:

$$Q = nC_p\Delta T$$

In this case, we want to use the heat capacity, moles and temperature change of the water. Another important equation is used to calculate how much energy you might predict has been given off in a reaction. The heat of solution is given by

$$\Delta Hn = Q$$

Where n is the number of moles of our salt and ΔH is the change in enthalpy per mole of our system. Enthalpy is a special measure of energy in a system. In this case, it is the energy required

to dissolve our salt. Enthalpy is also applied to chemical reactions and other energy equations in engineering.

Part III: Background Questions

Based on personal experience and intuition, answer the following questions:

1. What type of cup do you think would be the best for retaining heat? Why?

2. What materials do you think would improve any cups' insulating properties?

3. Which do you think is a better insulator: aluminum foil or cloth?

4. Where might a calorimeter lose heat?
