Lab 2 What is Energy?

Name: ______________________ Lab Partner(s): ______________________

Driving Question

Energy is involved in everything that happens, from the tiniest insect moving one antenna to a massive eruption of a volcano that spreads ash around the globe. Energy is constantly being transferred and transformed. If you use a microwave oven to heat your food, electromagnetic energy is transferred into the food and transformed into thermal energy. When you eat the food, your body turns the chemical energy in the food into a different form of chemical energy. If you kick a ball, you transfer some of the energy from your body into the ball.

There are two broad categories of energy: potential and kinetic. Potential energy is energy that is stored. Forms of potential energy include chemical, gravitational, elastic, and nuclear. Kinetic energy is the energy of motion. Electrical, radiant, thermal, and sound energy are all examples of kinetic energy.

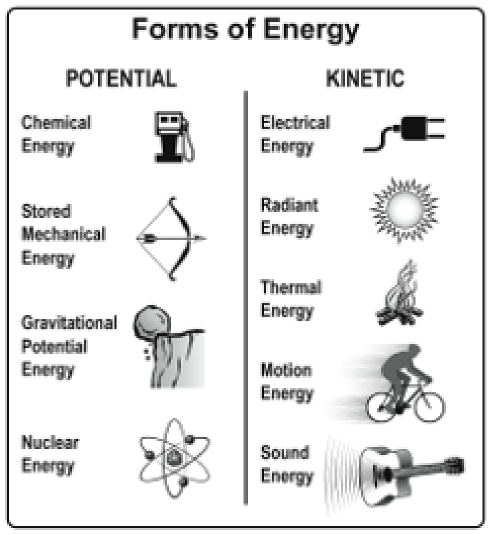

Figure 1: Adapted with permission from The NEED Project, `www.need.org`

Electrical energy is a convenient form of energy to transmit, sell, and use. Most electrical energy in the United States is generated from energy stored in fossil fuels, such as natural gas and coal. While these sources are forms of potential energy, they do not necessarily contain the same amount of energy per volume. To make it more complicated, different fuels are sold in different units of volume. We can use equations to calculate energy content and compare energy sources.

For example, if your house is heated with natural gas, you get a bill that tells them how much natural gas in cubic feet (ft^3) was used. If your friend's house is heated with a furnace that uses heating oil, your friend gets a bill that tells them how many gallons of oil were used. Imagine that your family used 14,300 ft^3 of natural gas last month, and that in the same month, your friend's family used 110 gallons of heating oil. Who used more energy to heat their home? You will answer this question in the Preliminary Questions.

In order to be able to compare energy sources more easily, conversion into measurements of a common unit is necessary. The SI unit for energy is the joule (J). In this experiment, you will determine the energy content in J/g of different fuels. You will do this by burning a known mass of the fuel and calculating the heat transferred to a known mass of water in a can. If you measure the initial and final temperatures, the energy transferred can be calculated using the equation

$$Q = mc\Delta T, \tag{1}$$

where Q is the heat energy absorbed (in J), ΔT is the change in temperature (in °C), m is the mass (in g), and c is the specific heat capacity (4.18 J/g°C for water). Dividing the resulting energy value by grams of fuel burned gives the energy content per unit of mass.

Objectives

- Identify the units that are used to measure energy.
- Determine the energy content of fuels by mass.

Materials

- Data collection system
- Fast probe temperature sensor
- Safety goggles
- 50 mL graduated cylinder
- Ring stand and 10 cm (4”) ring
- Utility clamp
- Fuel samples (candle and gel chafing fuel)
- Balance (0.01g precision)
- Matches
- Small can
- Ice water
- Pencil
- Stirring rod

Consider

1. List activities in your life that rely on fossil fuels.

2. What energy sources are used to generate electricity and heat in your region?

3. Are renewable fuel sources available in your region? If yes, what options are available?

4. You were presented with a problem in the introduction to this experiment. There are two households that use different types of fuel for heating. Last month, Household A (your house) used 14,300 ft^3 of natural gas and Household B (your friend's house) used 110 gallons of heating oil. Use the information below to determine which household used the most energy.

   Note: 1 ft^3 of natural gas contains 1.08×10^6 J and 1 gallon of heating oil contains 1.46×10^6 J

Investigate

1. Obtain and wear goggles.
2. Open *SPARKvue* and build a page with a graph display.
3. Connect the temperature probe. To do so, click the Hardware Setup icon at the bottom-right of the page, select the analog channel that the probe is connected to, and select Temperature Sensor (Stainless Steel).
4. Place Temperature on the y-axis.
5. Measure the initial mass of the candle or gel chafing fuel and record the value in Table 1.

6. Set up the equipment (see Figure 2).
   (a) Measure the mass of the empty can and record the value in Table 1.
   (b) If you are using a candle as your fuel source, place 50 mL of cold water into the can. If you are using gel chafing fuel, place 100 mL of cold water in the can.
   (c) Measure the mass of the can plus water and record the value in Table 1.
   (d) Use a 10 cm ring and a pencil through the can to suspend the can about 5 cm above the candle or chafing fuel.
   (e) Use the utility clamp to suspend the temperature sensor in the water. The temperature sensor should not touch the bottom or sides of the can.

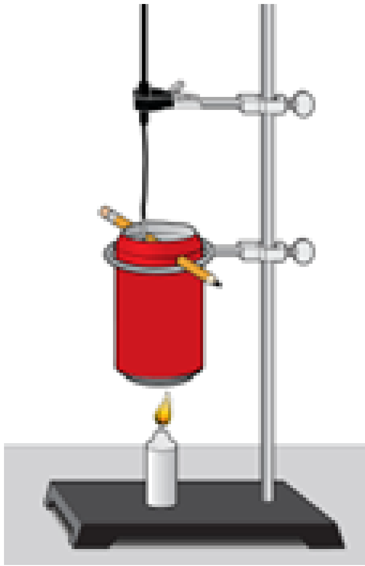

Figure 2: Experimental setup

7. Start data collection. Monitor temperature for about 10 seconds and record the initial temperature of the water in Table 1. Light the gel chafing fuel or candle. Heat the water until the temperature reaches about 35°C and then extinguish the flame.
   Caution: Keep hair and clothing away from an open flame.
8. Stir the water with a stirring rod until the temperature stops rising. Record the final temperature (round to the nearest 0.1°C) in Table 1.
9. A graph of temperature vs. time is displayed. To examine the data pairs on the displayed graph, tap any data point. Confirm the initial and maximum values you recorded earlier.
10. Measure the final mass of the candle or gel chafing fuel and record the value in Table 1.
11. Repeat data collection using a different fuel. Start with a new volume of cold water.

Processing the Data

1. Calculate the change in water temperature, ΔT, for each sample by subtracting the initial temperature from the final temperature. Record your answers in Table 1.
2. Calculate the mass of the water heated for each sample. Subtract the mass of the empty can from the mass of the can plus water. Record your answers in Table 1.
3. Use the results to determine the heat energy gained by the water (in J). To do so, use the equation

$$Q = mc\Delta T$$

   where Q is the heat energy absorbed (in J), ΔT is the change in temperature (in °C), m is the mass (in g), and c is the specific heat capacity (4.18 J/g°C for water). Record your answers in Table 1.
4. Calculate the mass of fuel burned. Subtract the final mass from the initial mass. Record your answers in Table 1.
5. Use the results to calculate the energy content (in J/g) of the fuel samples. Record your answers in Table 1.
6. Obtain the results of other groups and create a table with the compiled data.

Table 1		
	Candle	Gel chafing fuel
Initial mass of fuel (g)		
Final mass of fuel (g)		
Mass of fuel burned (g)		
Mass of empty can (g)		
Mass of can plus water (g)		
Mass of water (g)		
Initial water temperature (°C)		
Final water temperature (°C)		
Change in water temperature (°C)		
Energy content (J/g)		

Analysis Questions

1. Which of the fuels you tested has the greatest energy content?

2. Natural gas has an energy content of 53,600 J/g. Heating oil has an energy content of 46,200 J/g. How do the energy content values for these two types of fossil fuels compare to the energy content values that you

determined?

3. In addition to energy content, what are at least two other factors that might be important in choosing a fuel?

Extend

1. Research accepted values for the energy content of the fuels you tested in this experiment. Account for the differences that you find between the accepted values and the values you determined.

2. Research accepted values for the energy content of other common energy sources. How do they compare to the fuels you studied in this experiment and to natural gas and heating oil? If you were designing a heating system for a house, what energy source would you use? Take into consideration cost and availability.