Name _____

Date _____ Class _____

ChemFile LAB PROGRAM

EXPERIMENT A18

Heat of Combustion

OBJECTIVES

- **Measure** the change in temperature of a mass of water after heating it with a candle.
- **Use** the change in temperature, mass of the water, and specific heat of water to compute the energy released.
- **Determine** the energy released per mole of candle wax, or the heat of combustion.
- **Relate** heat of combustion to nutritional calories in food.

INTRODUCTION

The heat released by the complete combustion of one mole of a substance is called the *heat of combustion* of the substance. The *calorie* is sometimes used as the unit of energy for the heat of combustion because the nutritional Calorie content of foods is determined this way. The SI equivalent of one calorie is 4.184 joules. The calorie is defined as the quantity of heat required to raise the temperature of one gram of water one degree Celsius.

In this experiment, you will determine the heat of combustion of candle wax. A burning candle will heat a measured volume of water. You will observe the temperature change of the water. With this information you can calculate the heat released in the burning of the candle. The heat in calories is equal to the product of the mass of the water, its change in temperature, and the specific heat of water (1 cal/g • °C). With the molecular formula for candle wax and the mass of the wax consumed, the heat of combustion in calories per mole can be calculated.

SAFETY

Always wear goggles and a lab apron to provide protection for your eyes and clothing. If you get a chemical in your eyes, immediately flush the chemical out at the eyewash station while calling to your teacher. Know the location of the emergency lab shower and the eyewash station and the procedure for using them.

Call your teacher in the event of a spill. Spills should be cleaned up promptly, according to your teacher's directions.

When you use a candle, confine long hair and loose clothing. If your clothing catches on fire, WALK to the emergency lab shower and use it to put out the fire. Do not heat glassware that is broken, chipped, or cracked. Use tongs or a hot mitt to handle heated glassware and other equipment because hot glassware does not look hot.

MATERIALS

- 10 oz. tin can, open at one end
- 46 oz. tin can, open at both ends
- 100 mL graduated cylinder
- candle
- crucible tongs
- glass stirring rod
- ice cubes
- iron ring
- matches
- ring stand
- thermometer, nonmercury
- thermometer clamp
- tin can lid

PROCEDURE

1. Attach the candle to a tin can lid by lighting the candle and allowing a few drops of candle wax to drip on the lid before placing the candle on the lid. The tin can lid will be used to support the candle and collect any melted wax that runs down the side of the candle. The mass of the melted wax must be included in the mass of the candle after burning.

2. Obtain the mass of the candle and lid to the nearest 0.01 g, and record the mass in the Data Table.

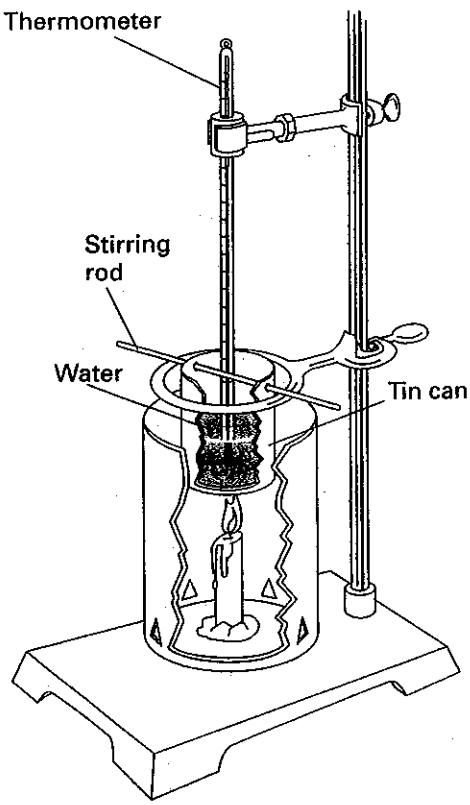

FIGURE A

3. Insert the glass stirring rod through the two small holes on the sides of the small tin can. Support the can by the stirring rod on the iron ring and ring stand as shown in Figure A. With your candle in place, raise or lower the can to position it so that the bottom is approximately 5 cm above the top of the wick. The flame of the candle should just barely miss touching the bottom of the can. (You may wish to light the candle for a moment to see if you have the correct height.) Remove the can and stirring rod from the iron ring.

4. Place the large can over the candle. Make sure the air vents are at the bottom. Clamp a thermometer to the ring stand as shown in Figure A. Record the room temperature in the Data Table.

5. Fill the small can about half-full with tap water. Cool the water with ice until the temperature is 10–15°C below room temperature. Remove any remaining ice. Read and record the temperature of the water to the nearest 0.1°C.

6. Using crucible tongs to hold the match, light the candle. Immediately position the can of cold water on the iron ring and adjust the thermometer. While the candle heats the water, gently stir with a stirring rod. Make sure the lid catches all the drippings.

7. When the temperature is approximately the same number of degrees above room temperature as it was below, blow out the candle. Continue to stir the water and watch the temperature until the maximum temperature is reached. Record this temperature to the nearest 0.1°C.

8. Obtain the mass of the candle and lid to the nearest 0.01 g.

9. Use a graduated cylinder to measure the total volume of water in the can, and record the volume to the nearest 1 mL.

Cleanup and Disposal

10. Clean all apparatus and your lab station. Return equipment to its proper place. Wash your hands thoroughly before you leave the lab and after all work is finished.

Data Table

Initial mass of candle and base	g
Room temperature	°C
Initial temperature of water	°C
Final temperature of water	°C
Final mass of candle and base	g
Volume of water	mL

CALCULATIONS

1. **Organizing Data** Calculate the change in the temperature of the water. Record this result and all others in your calculations table.

2. **Organizing Data** Determine the mass of the water. (Hint: The density of water is 1.00 g/mL.)

3. **Organizing Data** Calculate the number of calories of heat absorbed by the can of water. (Hint: calories = mass of water × temperature change of water × specific heat of water in cal/g°C)

4. **Organizing Data** Calculate the mass of the candle wax that burned.

5. **Organizing Data** Calculate the heat released in the burning of one gram of candle wax.

6. **Inferring Conclusions** Your candle was probably made of a mixture of waxes, mostly paraffin waxes. Paraffin waxes are hydrocarbons with high molecular masses. Assume the molecular formula of the candle wax is $C_{36}H_{74}$. Calculate the heat of combustion of the candle wax in kcal/mol.

7. **Inferring Conclusions** Convert the heat of combustion from Calculations item **6** to SI units of kJ/mol. (Hint: One calorie equals 4.184 J.)

QUESTIONS

1. **Analyzing Methods** Explain the purpose of cooling the water to 10–15°C and then heating the water to the same number of degrees above room temperature.

2. **Analyzing Methods** Was all the heat released in the burning of the candle absorbed by the water? If not, what happened to the missing heat?

GENERAL CONCLUSIONS

1. **Relating Ideas** A nutritional Calorie is a kilocalorie, or 1000 calories. The number of Calories that are in the foods you eat is determined using a precise bomb calorimeter, but the principle involved in the process is the same as that used in this experiment. Burning a peanut in a bomb calorimeter releases enough energy to raise the temperature of 500 grams of water by 10°C.
   a. How many calories are contained in a peanut?

   b. How many nutritional Calories are contained in a peanut?