PRELIMINARY ACTIVITY FOR

Investigating the Energy Content of Fuels

Open Inquiry Version

Hydrocarbons are compounds containing only hydrogen and carbon atoms. Many common fuels such as gasoline, diesel fuel, heating oil, aviation fuel, and natural gas are essentially mixtures of hydrocarbons. Paraffin wax, used to make many candles, is a mixture of hydrocarbons with the representative formula $C_{25}H_{52}$.

Ethanol, a substituted hydrocarbon with the formula CH_3CH_2OH, is used as a gasoline additive (gasohol) and as a gasoline substitute. Ethanol is an *alcohol*—a hydrocarbon derivative in which one or more hydrogen atoms has been replaced by a hydroxyl group (–OH). 1-propanol ($CH_3CH_2CH_2OH$), 2-propanol ($CH_3CH(OH)CH_3$), and 1-butanol (CH_3CH_2 CH_2CH_2OH) are other common alcohols.

In the Preliminary Activity, you will determine the heat of combustion of paraffin wax (in kJ/g). You will first use the energy from burning paraffin wax to heat a known quantity of water. By monitoring the temperature of the water, you can find the amount of heat transferred to it (in kJ), using the formula

$$q = C_p \cdot m \cdot \Delta t$$

where q is heat, C_p is the specific heat capacity of water, m is the mass of water, and Δt is the change in temperature of the water. Finally, the *amount* of fuel burned will be taken into account by calculating the heat *per gram* of paraffin wax consumed in the combustion.

After completing the Preliminary Activity, you will first use reference sources to find out more about calorimetry and fuels before you choose and investigate a researchable question. Some topics to consider in your reference search are:

- calorimetry
- combustion
- fuels
- fossil fuels
- hydrocarbons
- alcohols
- ethanol
- gasohol
- energy efficiency

PROCEDURE

1. Obtain and wear goggles.
2. Connect the Temperature Probe and the data-collection interface.
3. Set up the data-collection program up to collect data for twenty minutes following your instructor's directions.
4. Use some melted wax to affix a candle to a small index card.
5. Find and record the combined mass of the candle and index card.

6. Determine and record the mass of an empty can. Add 100 mL of chilled water to the can. Determine and record the mass of the can and water.

7. Set up the apparatus as shown in Figure 1. Use a ring and stirring rod to suspend the can about 5 cm above the wick. Use a utility clamp to suspend the Temperature Probe in the water. The probe should not touch the bottom of the can. **Important:** Stir the water until the Temperature Probe has cooled to the temperature of the water before you do Step 8.

8. Begin data collection. After about 15 seconds, light the candle. Record the initial temperature. Heat the water until its temperature reaches 40°C and then extinguish the flame. **CAUTION:** *Keep hair and clothing away from an open flame.*

9. Stir the water, and continue stirring it until the temperature stops rising. Record this final temperature, and then stop data collection.

10. Determine and record the final mass of the cooled candle and index card, including all drippings.

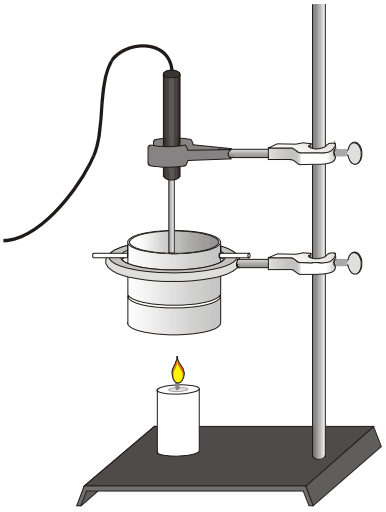

Figure 1

QUESTIONS

1. Find the mass of water heated.

2. Find the change in temperature of the water, Δt.

3. Calculate the heat absorbed by the water, q, using the formula in the introduction of this experiment. For water, C_p is 4.18 J/g°C. Change your final answer to kJ.

4. Find the mass of paraffin wax burned.

5. Calculate the heat of combustion for paraffin wax in kJ/g. Use your Step 3 and Step 4 answers.

6. Calculate the *% efficiency* of the experiment. Divide your experimental value (in kJ/g) by the accepted value, and multiply the answer by 100. The accepted heat of combustion of paraffin wax is 41.5 kJ/g.

7. Discuss heat loss factors that contribute to the inefficiency of the experiment.

8. List at least one researchable question concerning the energy content of fuels.

Note: The plan that you submit for instructor approval should list laboratory safety concerns, including chemical safety concerns, and specify how you will address these safety concerns during your investigation.

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Investigating Chemistry though Inquiry* lab manual includes 25 inquiry-based labs and essential teacher information. The full lab book is available for purchase at: http://www.vernier.com/cmat/chemi.html

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