

Investigation 9.B: Molar Enthalpy of Combustion

You have probably gazed into a candle flame, a roaring fire, or your gas barbecue without thinking about chemistry! Now, however, you will use the combustion of candle wax to gain insight into the measurement of heat exchanges. With this experience, you will then design a procedure to compare the molar enthalpies of paraffin and two other fuels. You will also evaluate the design of this investigation and make suggestions for improvements.

Questions

1. What is the molar enthalpy of combustion of paraffin?
2. How can you compare the molar enthalpies of combustion for several different fuels?

Safety Precautions

- Tie back long hair and secure any loose clothing. Before you light any fuel source, check that there are no flammable solvents nearby.

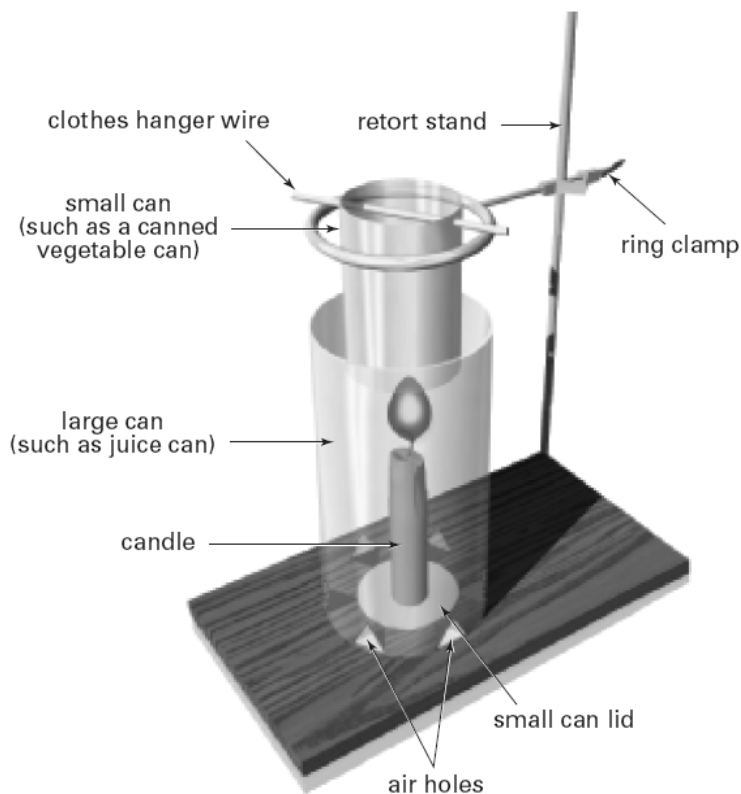
Part 1: The Molar Enthalpy of Combustion of Paraffin

Materials

- candle
- water
- matches
- balance
- calorimeter
- apparatus: includes retort stand, large can with air holes, small can, ring clamp, wire or stirring rod
- thermometer (alcohol or digital)
- stirring rod
- can lid or cardboard base

Procedure

1. Light the candle to melt some wax. Drip the wax onto the base and attach the candle to it. Blow out the candle.
2. Set up the apparatus as shown, but do not include the large can yet. Adjust the ring stand so that the small can is about 5 cm above the wick of the candle. When the candle is lit, the tip of the flame should just touch the bottom of the small can.
3. Measure the mass of the candle and the base.
4. Measure the mass of the small can. Measure the mass of the hanger.
5. Place the candle inside the large can on the retort stand.



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6. Fill the small can about two thirds full of cold water (10 °C to 15 °C). You will measure the mass of the water later.
7. Stir the water in the can. Measure the temperature of the water.
8. Light the candle. Quickly place the small can in position over the candle. **Caution:** Be careful of the open flame.
9. Continue stirring. Monitor the temperature of the water until it has reached 10 °C to 15 °C above room temperature.
10. Blow out the candle. Continue to stir. Monitor the temperature until you observe no further change.
11. Record the highest temperature reached. Examine the bottom of the container and record your observations.
12. Measure the mass of the small can and the water.
13. Measure the mass of the candle, base, and any drops of candle wax.

Analysis

1. (a) Calculate the mass of the water.

(b) Calculate the mass of candle wax that was burned.

2. Calculate the molar enthalpy of combustion of paraffin wax.
 - Assume that the candle wax is pure paraffin wax.
 - Include the mass of the small can in your calculations as part of the calorimeter. Ask your teacher for the composition of the can.

heat lost by system = –heat gained by surroundings = –(heat gained by water + heat gained by can)

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Conclusion

3. (a) List some possible sources of error that may have affected the results you obtained.

(b) Evaluate the design and the procedure of this investigation. Think about the assumptions that are made in calorimetry calculations. Consider the apparatus, the combustion, and anything else you can think of. Make suggestions for possible improvements.

4. What if soot (unburned carbon) accumulated on the bottom of the small can? Would this produce a greater or lower heat value than you expected? Explain.

Part 2: Comparing the Molar Enthalpies of Combustion for Three Fuels

Materials

- water
- two fuels other than paraffin
- matches
- calorimeter apparatus:
includes retort stand, large can with air holes, small can, ring clamp, wire or stirring rod
- balance
- thermometer (alcohol or digital)
- stirring rod
- can lid or cardboard base

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Experimental Plan

1. List the variables for your investigation: manipulated, responding, and controlled.

2. Write a procedure that you will carry out for each fuel.

3. Design a data table to record your data.

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4. Think about the calculations that you will have to perform to calculate molar enthalpy of combustion. Are you collecting enough data?

5. You have to be able to compare the three fuels (the two other fuels plus the paraffin) fairly. Are you controlling all the variables that should be controlled?

Data and Observations

6. Perform your investigation. Record all data.

Analysis

1. Calculate the molar enthalpy of combustion for the other two fuels.

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Conclusion

2. (a) Write a balanced thermochemical equation for the complete combustion of paraffin wax and of the other two fuels you studied.

(b) Draw an enthalpy diagram for each fuel.

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3. Compare the three fuels. Your answer should include:

- a statement about the relative molar enthalpies of combustion
- the environmental impact of each fuel
- the appropriate uses of each fuel and why they are appropriate

Use an Internet search to obtain information to satisfy the last two bulleted points. **ICT**

Extension

4. Repeat this experiment using food instead of fuel. What aspects other than enthalpy of combustion are important in evaluating the appropriateness of food that may be taken on a survival hike? Explain.