

Evaporation of Alcohols

The evaporation of a liquid absorbs energy and cools its surroundings. Such a process is said to be *endothermic*. You have probably experienced this phenomenon as you stepped from a swimming pool on a windy day. A major factor in determining the rate of evaporation and the resulting cooling is the strength of attraction between the molecules of a liquid. Substances with strong attractions between molecules evaporate slowly and cool slightly during evaporation. In this experiment, you will study temperature changes caused by the evaporation of different alcohols.

OBJECTIVES

In this experiment, you will

- draw structural formulas for alcohols
- measure temperatures as three alcohols evaporate
- determine the change in temperature, Δt , for each of three alcohols
- predict the change in temperature, Δt , for a fourth alcohol
- determine the change in temperature, Δt , for the fourth alcohol
- graph the results
- use the results to make conclusions about intermolecular attractions

MATERIALS

Macintosh or IBM-compatible computer
Serial Box Interface or ULI
Logger *Pro*
2 Vernier Temperature Probes
four 1" \times 1" pieces of paper
4 small rubber bands, from braces

methanol, CH_3OH
ethanol, $\text{C}_2\text{H}_5\text{OH}$
1-propanol, $\text{C}_3\text{H}_7\text{OH}$ - in beaker
1-butanol, $\text{C}_4\text{H}_9\text{OH}$
tape

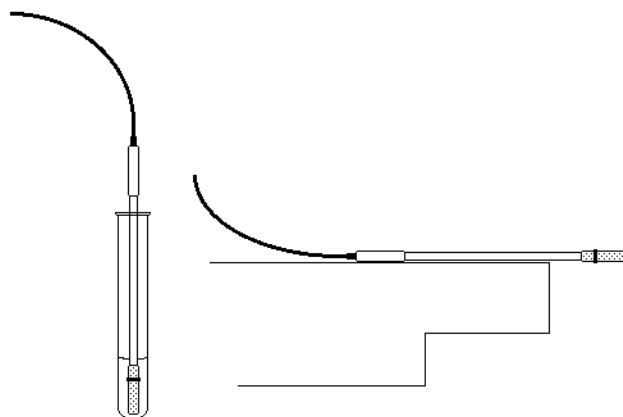






Figure 1

PRE-LAB EXERCISE

In the space supplied on the third page of this experiment, draw structural formulas for methanol, ethanol, 1-propanol, and 1-butanol.

PROCEDURE

1. Obtain and wear goggles! **CAUTION:** *The alcohols used in this experiment are flammable and poisonous. Avoid inhaling their vapors. Avoid contacting them with your skin or clothing.*
2. Prepare the computer for data collection by opening “Exp 04” from the *Physical Science with Computers* experiment files of *LoggerPro*. The vertical axis of the graph will have temperature scaled from 5 to 30°C. The horizontal axis will have time scaled from 0 to 200 seconds.
3. Wrap the temperature probes with 1" x 1" pieces of paper secured with small rubber bands as shown in Figure 1. Hint: First slip the rubber band up on the probe, then wrap the paper around the probe, and then finally slip the rubber band over the wrapped paper. The paper should be even with the probe end.
4. Stand Probe 1 in the methanol container and Probe 2 in the ethanol container. Make sure the containers do not tip over.
5. Obtain two pieces of tape, each about 10 cm long, to tape the probes in position during Step 6.
6. After the probes have been in the liquids for at least 45 seconds, click  to begin data collection. Monitor the temperature for 15 seconds to establish the initial temperature of each liquid. Then remove the probes from the liquids and tape them with the probe tips extending 5 cm (2 inches) over the edge of the table top as shown in Figure 1.
7. When both temperatures have reached minimums and have begun to increase, click  to end data collection. Click the Statistics button, , then click  to display a box for both probes. Record the minimum and maximum temperature for Temperature 1 (methanol) and Temperature 2 (ethanol).
8. Roll the rubber band up the probe shaft and dispose of the filter paper as directed by your teacher.
9. Choose Delete Column ► Temperature 2 from the Data menu to turn off Probe 2. Repeat Steps 3-7 using Probe 1 and 1-propanol.
10. Delta (Δ) means “change in.” For each liquid, subtract the minimum temperature from the maximum temperature to determine Δt , the temperature change during evaporation. Do this in the space supplied in the Data and Calculations Table.
11. Using the chemical formulas and Δt values for methanol, ethanol, and 1-propanol, predict the Δt for 1-butanol. Explain how you arrived at this value.
12. Test your prediction by repeating Steps 3-7 using 1-butanol and Probe 1.

PRE-LAB EXERCISE

Draw structural formulas for the alcohols. All four are unbranched with the -OH group on an end carbon atom. You may use your book as a guide, page 362, Table 13-1.

methanol, CH₃OHethanol, C₂H₅OH1-propanol, C₃H₇OH1-butanol, C₄H₉OH**DATA AND CALCULATIONS**

Liquid	methanol	ethanol	1-propanol
Max Temp	_____ °C	_____ °C	_____ °C
Min Temp	_____ °C	_____ °C	_____ °C
Δt	_____ °C	_____ °C	_____ °C

Predicted Δt for 1-butanol, C₄H₉OH, = _____ °C.

Explanation:

Results for 1-butanol:

Max Temp	_____ °C
Min Temp	_____ °C
Δt	_____ °C

PROCESSING THE DATA

1. Prepare a bar graph of the results on a sheet of graph paper. Plot number of carbon atoms in the alcohol on the horizontal axis and Δt (in $^{\circ}\text{C}$) on the vertical axis.
2. How good was your predicted value for the Δt of 1-butanol? Explain.
3. Which of the alcohols studied has the strongest attractions between its molecules? The weakest attractions? Explain, using the results of this experiment.

EXTENSIONS

1. Predict the order of the boiling temperatures for the four alcohols studied in this experiment. Use the results of the experiment to explain your predictions. To check your predictions, look up the boiling temperatures or use a procedure similar to that outlined in Experiment 2, "Boiling Temperature of Water," to determine the values. Heat 5-mL samples of the alcohols in 18 X 150 mL test tubes. Use a hot-water bath on a hot plate to heat the test tubes containing the alcohols.
2. Use Graphical Analysis to prepare the bar graph asked for in Step 1 of Processing the Data. Compare your two graphs.