PROBEWARE INVESTIGATION 9 • A

Properties of Hydrocarbons

Question
How do the intermolecular forces compare within two types of organic compounds — alkanes and alcohols?

Prediction
Make a prediction on the temperature changes within various alkanes and alcohols.

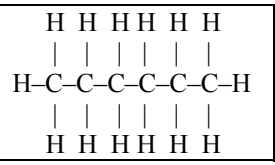
Materials
computer system and interface
two temperature sensors
2 small elastic bands
6 square pieces of filter paper (2.5 × 2.5 cm)
6 test tubes (25 × 200 mm)
test tube rack
masking tape
25 mL each of ethanol (C_2H_5OH), 1-propanol (C_3H_7OH), 1-butanol (C_4H_9OH), pentane (C_5H_{12}), methanol (CH_3OH), and hexane (C_6H_{14})

Safety Precautions

[CAUTION]: Many of the substances involved are highly flammable and can give off dangerous vapours. The fume hood must be used for this investigation so that the fumes can be expelled. Note: Take care to dispose of materials properly.

Procedure
1. Copy the data table below into your notebook.

Substance	Formula	Structural Formula	Molar Mass	Max. Temp. (°C)	Min. Temp. (°C)	ΔT due to evaporation (°C)
ethanol	C_2H_5OH	H H | | H–C–C–O–H | | H H	46 g/mol			
1-propanol	C_3H_7OH	H H H | | | H–C–C–C– O–H | | | H H H	60 g/mol			
1-butanol	C_4H_9OH	H H H H | | | | H–C–C–C–C–O–H | | | | H H H H	74 g/mol			
pentane	C_5H_{12}	H H H H H | | | | | H–C–C–C–C–C–H | | | | | H H H H H	72 g/mol			
methanol	CH_3OH	H | H–C–O–H | H	32 g/mol			

hexane	C_6H_{14}		86 g/mol			

2. Set up the computer system with the temperature sensor. The sensor should be set to monitor temperature once per second.

3. Display the sensor with a graph display (temperature vs. time) and digits display.

4. Wrap the small elastic band securely (but not too tightly) around the base of each temperature sensor and roll them halfway up the sensors.

5. Wrap a square piece of filter paper into a cylinder shape around the tip of each of the 2 temperature sensor ends. The paper should be even with the sensor end. Roll the elastics down around the middle of each filter paper to hold them in place.

6. Place 25 mL of each of the six samples in the six labelled test tubes.

7. Place sensor A into the test tube of ethanol and sensor B into the test tube of 1-propanol for 1 minute.

8. Start the data collection.

9. Simultaneously remove the sensors from both liquids and tape them onto the edge of the fume hood with masking tape so the sensor tips extend 5 cm over the edge of the tabletop. Air should be able to move freely on all sides of both sensors.

10. When both temperatures have reached minimums and have begun to increase, stop the data collection.

11. Dispose of the filter paper as directed by your teacher.

12. For both liquids, determine the temperature change ΔT during evaporation by subtracting the minimum temperature from the maximum temperature.

13. Repeat steps 3 to 11 for 1-butanol with sensor A and pentane for sensor B.

14. Repeat steps 3 to 11 for methanol with sensor A and hexane for sensor B.

15. Discard the solutions as directed by your teacher. Do not pour anything down the drain. Wash your hands thoroughly.

Analysis

1. Prepare a graph of ΔT values of the four alcohols versus their respective molar masses. What is the relationship between molar mass and ΔT due to evaporation?

2. Is the process of evaporation endothermic or exothermic?

3. Which of the alcohols had the smallest change in temperature? What does this tell you about the intermolecular forces of attraction for this alcohol?

4. Which of the alcohols had the greatest change in temperature? What does this tell you about the intermolecular forces of attraction for this alcohol?

5. Which of the alkanes had the smallest change in temperature? What does this tell you about the intermolecular forces of attraction for this alkane?

6. Which of the alkanes had the greatest change in temperature? What does this tell you about the intermolecular forces of attraction for this alkane?

7. In general, the more polar the molecule is, the greater the intermolecular forces. Using your data, which of the liquids you tested do you think is most polar?

Conclusions

8. With increasingly larger alcohol molecules, does ΔT due to evaporation increase or decrease?

9. With increasingly larger alkane molecules, does ΔT due to evaporation increase or decrease?

Applications

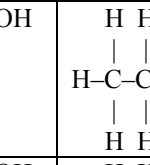
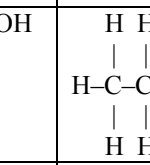
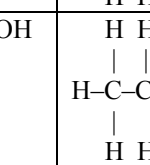
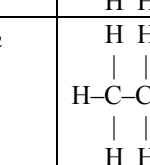
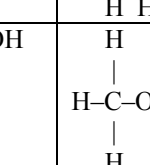
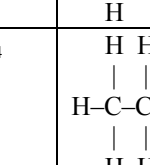
10. Predict how ΔT due to evaporation of water (a polar liquid) would compare with any of the liquids you tested in this experiment.

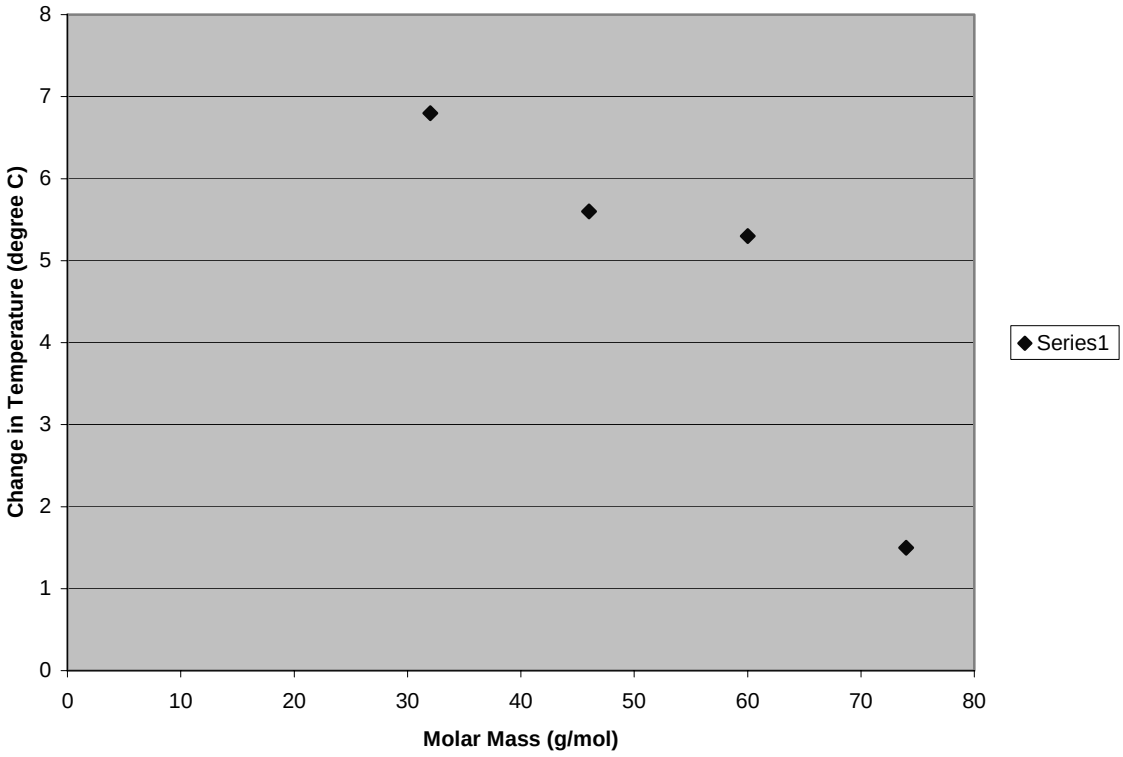
11. Measure and compare ΔT due to evaporation between 95% isopropyl alcohol to that of 70% isopropyl alcohol. Use the fume hood for this measurement.

Teacher Information

Sample Data – Answer Sheet

Observations

Substance	Formula	Structural Formula	Molar Mass	Max. Temp. (°C)	Min. Temp. (°C)	ΔT due to evaporation (°C)
ethanol	C_2H_5OH		46 g/mol	19.5	13.9	5.6
1-propanol	C_3H_7OH		60 g/mol	19.7	14.4	5.3
1-butanol	C_4H_9OH		74 g/mol	19.4	17.9	1.5
pentane	C_5H_{12}		72 g/mol	20.1	14.0	6.1
methanol	CH_3OH		32 g/mol	19.6	12.8	6.8
hexane	C_6H_{14}		86 g/mol	20.0	15.5	4.5



1. The larger the molar mass, the smaller ΔT due to evaporation.

2. endothermic

3. 1-butanol; strong

4. methanol; weak

5. hexane; strong

6. pentane; weak

7. 1-butanol

8. decrease

9. decrease

10. & 11. Answers will vary.