Experiment

10 The strength of intermolecular forces

Background

Intermolecular attraction can be classified into three categories: Dispersion forces, dipole-dipole forces and hydrogen bonding. The relative strengths of these intermolecular forces influence the temperature at which molecular substances change state (e.g. boiling point, melting point) and the quantity of heat required for the substance to change state (heat of fusion, heat of vaporisation). The strength of intermolecular forces also influences the rate of evaporation of liquids. Evaporation is the change of state from liquid to gas that takes place at any temperature below the boiling point. When substances evaporate they absorb energy from the surroundings and produce a cooling effect.

liquid + energy → gas

In this experiment you will compare the cooling effects of methanol, ethanol, 1-propanol and 1-butanol, and draw conclusions about the relative strengths of their intermolecular forces.

Equipment required

Temperature sensors (two or more depending on the number of sensors that the interface can accommodate)
Computer or graphic calculator loaded with temperature program
Computer or graphic calculator interface
Methanol (10 mL)
Ethanol (10 mL)
1- propanol (10 mL)
1- butanol (10 mL)
Filter paper squares (four, approximately 2 cm × 2 cm)
Small elastic bands (one for each temperature sensor)
Test tubes (four small)
Test tube rack

Procedure

#1 Construct the following table for the results and list the four liquids in the liquid column.

Liquid	Initial temperature	Final temperature	Change in temperature

#2 Ensure that the temperature sensors are connected to the interface and that the interface is connected to a computer or graphic calculator. Check that the temperature program has been loaded.

#3 Check that the temperature sensors have been calibrated. If this needs to be done, follow the software instructions. Use thermometers.

#4 Identify which temperature sensor is responsible for each set of data produced on the screen. This can be done by warming one of the sensors with your hand and observing the response on the screen.

#5 Wrap a small piece of square filter paper (2 cm × 2 cm) around each of the temperature sensors. The paper should be level with the end of the sensors and secured with a small rubber band that is as far away from the end of the sensor as possible.

#6 Place methanol, ethanol, 1-propanol and 1-butanol in each of the four test tubes to a depth of approximately 3 cm.

#7 Place one sensor in the methanol and the other in the ethanol for approximately 45 seconds to ensure that the filter paper is saturated. (The number of sensors used depends on the interface.) Then record the initial temperature of the solvents.

#8 While continuing to collect data, remove the sensors from the test tubes and place them on the bench so that the filter paper end of the sensor projects over the edge of the bench. Continue to collect data and to graph the temperature until the temperature appears to reach a minimum.

#9 Calculate the change in temperature that occurred when the methanol and ethanol evaporated. Enter your results in a table.

#10 If possible, store this data so that data for the remaining liquids can be added to them.

#11 Repeat steps 7–9 for the other liquids.

#12 Obtain a printout of your results.