Intermolecular Forces Lab

Teacher's Guide

This lab can be done with wireless temperature probes or analog thermometers. If wireless probes are used, the software that accompanies the probes can be used to graph the results in real time. If analog thermometers are used, the students will need to record data in a table and create their own graphs.

1. Have some students assemble two models of each compound, and use the models to discuss intermolecular forces, and then relate those forces to predict evaporation rates.

2. Make sure the Vernier Graphical Analysis app is downloaded to the iPad or iPhone that the students will use for the experiment.

3. Intermolecular forces present in each molecule:

Liquid	London Dispersion Forces	Dipole-Dipole Interactions	Hydrogen Bonds
1-propanol	X	X	X
water	X	X	X
glycerin	X	X	X
cyclohexane	X		
acetone	X	X	
methanol	X	X	X

4. The ranking from greatest to least intermolecular attraction is: glycerin (glycerol), 1-propanol, water, cyclohexane, methanol, acetone

5. The graph should resemble Figure 1 or Figure 2:

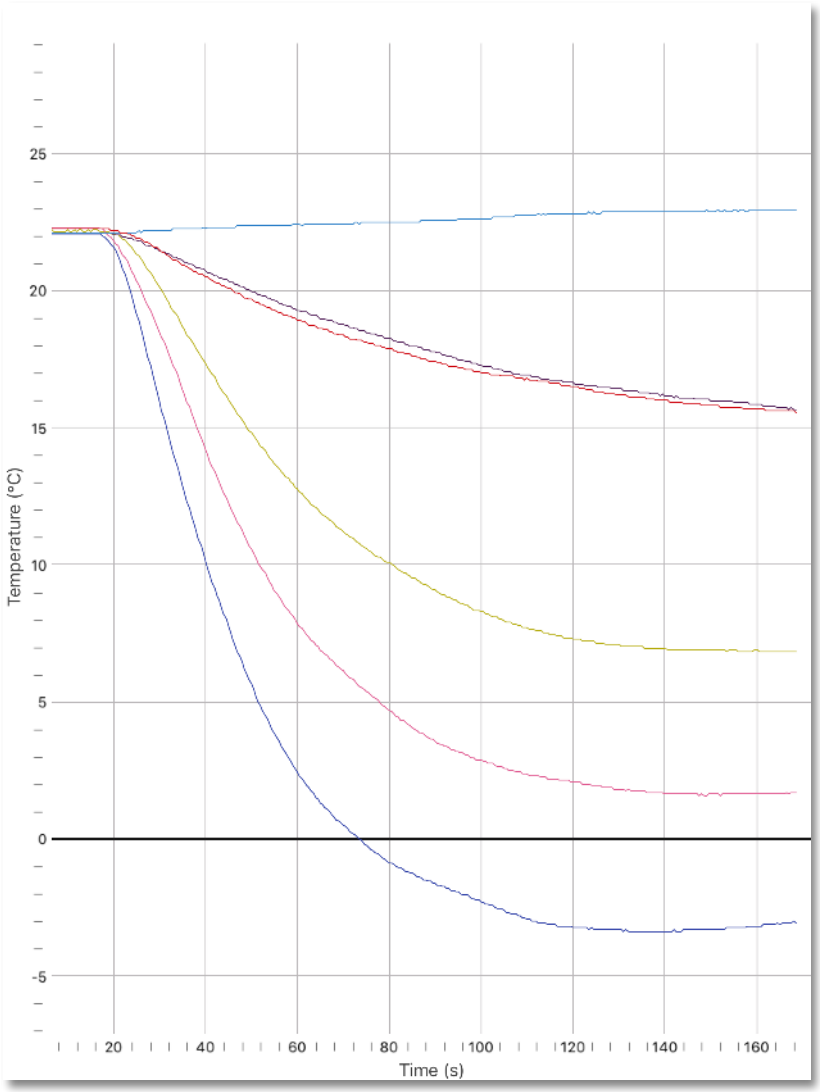
25
20
15
10
5
0
-5
Temperature (°C)
20
40
60
80
100
120
140
160
Time (s)

Fig. 1

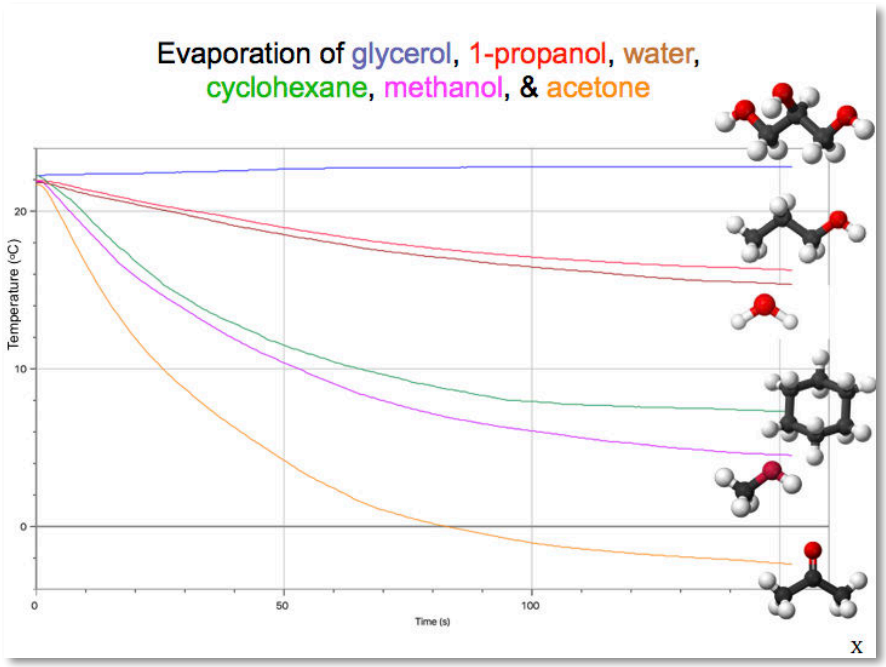
Evaporation of glycerol, 1-propanol, water,
cyclohexane, methanol, & acetone
Temperature (°C)
20
10
0
0
50
100
Time (s)
x

Fig. 2

6. Describe the graph and explain: Evaporation of the liquid requires heat absorption from the surroundings (the probe). Heat is absorbed faster by the molecules with the weaker intermolecular forces causing a faster drop in temperature. Heat is absorbed more slowly by the molecules with stronger intermolecular forces.

a. The probe in the glycerin did not record a drop in temperature (it stayed constant). Glycerin has the largest electron cloud (50) of the liquids in the lab which results in stronger dispersion forces and it has three hydrogens that can hydrogen bond.

b. 1-Propanol dropped about 5^{o}C. It has a electron cloud of medium size (34), is polar, and has one hydrogen that can hydrogen bond.

c. Water dropped about 6^{o}C. It has a small electron cloud (10), is polar, and has two hydrogens that can hydrogen bond.

d. Cyclohexane dropped about 15^{o}C. It has a relatively large electron cloud (48), is nonpolar, and can not hydrogen bond.

e. Methanol dropped about 20^{o}C. It has a relatively small electron cloud (18), is polar, has one hydrogen that can hydrogen bond.

f. Acetone dropped about 25^{o}C. It has a relatively small electron cloud (32), is polar, and can not hydrogen bond.

g. Conclusion: To determine the effect of intermolecular forces on physical properties, three factors should be considered: the size of the electron cloud (dispersion forces), dipole moment (polarity), and hydrogen bonding.

Intermolecular Forces Lab (Wireless Probes)

Student Procedure

Objective: To observe the rate of temperature change due to evaporation of six different liquids and then use intermolecular forces to explain the differences in evaporation rates.

Materials: iPad, Vernier Graphical Analysis App, 6 Vernier wireless temperature probes, paper towel, rubber bands, 6 small test tubes (10 ml), test tube rack, 1-propanol, cyclohexane, propanone (acetone), glycerol (glycerin), methanol, water.

1. Make two models of 1-propanol. Examine the models and describe the type and strength of intermolecular forces present. Repeat the process with cyclohexane, acetone, methanol, water, and glycerin. Use the web for reference.
2. Cut a paper towel into a piece about 2 cm by 6 cm, wrap each temperature probe, and secure with a small rubber band (see Figs. 1 and 2).

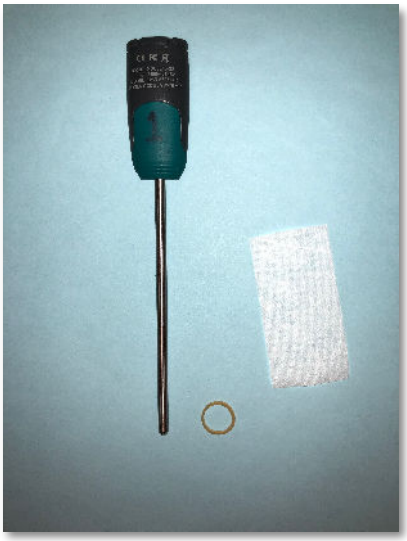

Fig. 1 Probe, paper towel and rubber band.

Fig. 2 Paper towel attached to probe.

3. Open the app: Graphical Analysis. Now connect the six temperature probes. Set these aside for a moment.
4. Add about 3 ml of each liquid to six different small test tubes and place them in a test tube rack.
5. Insert each temperature probe into a test tube containing the liquids (Fig. 3).

Fig. 3 Probes with towels attached placed in test tubes.

6. Click the "Collect" button. Simultaneously remove all six temperature probes, invert them and hold them so that they do not touch each other or the table (or anything else). Observe the graph displayed on the computer. Allow the data to collect for about 150 seconds, then click the "Stop" button.
7. Dispose of the 1-propanol, acetone, methanol, water, and glycerin into the sink and rinse with tap water. The cyclohexane should be place in a waste container (not in the sink).
8. Print or sketch the graph displayed on the iPad and answer the following questions:

a. Use the graph to rank the six liquids from most intermolecular forces to least intermolecular forces.

b. Which intermolecular forces are present in each of the liquids:

c. Explain the results of the experiment. Include the intermolecular forces at work in each substance.

Intermolecular Forces Lab (Analog Thermometers)

Student Procedure

Objective: To observe the rate of temperature change due to evaporation of six different liquids and then use intermolecular forces to explain the differences in evaporation rates.

Materials: 3 thermometers, paper towel, 3 rubber bands, 3 medium sized test tubes (30 ml), test tube rack, 1-propanol, cyclohexane, propanone (acetone), glycerol (glycerin), methanol, water.

1. Make two models of 1-propanol. Examine the models and describe the type and strength of intermolecular forces present. Repeat the process with cyclohexane, acetone, methanol, water, and glycerin. Use the web for reference.
2. Cut a paper towel into a piece about 2 cm by 6 cm, wrap each thermometer, and secure with a small rubber band. See Figs. 1 and 2.

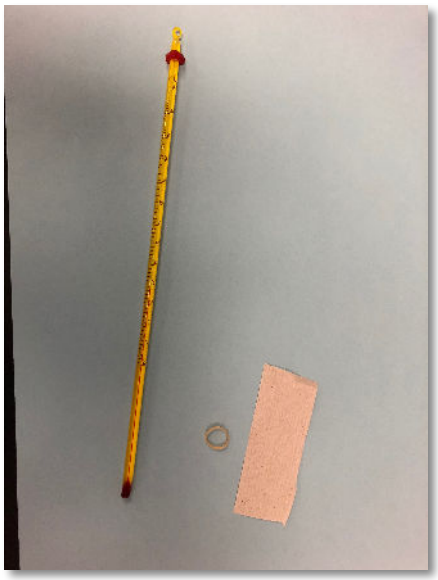

Fig. 1 Thermometer, paper towel and rubber band.

Fig. 2 Paper towel attached to thermometer.

3. Add about 5 ml of each liquid to six different small test tubes and place them in a test tube rack.
4. Insert the three thermometers into three different test tube containing the liquids. Record the temperature of the liquids. See Fig. 3.

Fig. 3 Thermometers with towels attached placed in test tubes.

5. Simultaneously remove three thermometers, invert them and hold them so that they do not touch each other or the table (or anything else). Read and record the temperature on each thermometer every 10 seconds for 2 minutes.
6. Repeat the experiment with the other liquids.
7. Dispose of the 1-propanol, acetone, methanol, water, and glycerin into the sink and rinse with tap water. The cyclohexane should be place in a waste container (not in the sink).
8. Create a graph of temperature vs time for each liquid.

d. Use the graph to rank the six liquids from most intermolecular forces to least intermolecular forces .

e. Which intermolecular forces are present in each of the liquids:

Liquid	London Dispersion Forces	Dipole-Dipole Interactions	Hydrogen Bonds
1-propanol			
water			
glycerin			
cyclohexane			
acetone			
methanol			

f. Explain the results of the experiment. Include the intermolecular forces at work in each substance.