Exploring Intermolecular Forces Lab

Background: Intramolecular forces are forces acting on atoms within ionic crystals or molecules. Intramolecular forces are responsible for many macroscopic properties such as electrical conductivity, hardness, and luster. Other properties of matter such as boiling point, vapor pressure, and surface tension are best explained by the **forces action between molecules**, **intermolecular forces.** In this experiment the surface tension of three liquids (water, isopropyl alcohol and glycerol) will be compared in order to assess the strength of their intermolecular forces. The stronger the intermolecular force the greater the surface tension. The intermolecular forces of these three substances will be further studied using a molecular model kit. Using the models, the nature of the attractive forces for various substances will be examined.

Objectives:

- Compare the surface tension of water, isopropyl alcohol and glycerol to assess the strength of their intermolecular forces.
- Construct models of these substances using a molecular model kit
- Describe the nature of the attractive forces for various substances

Materials:

3 Erlenmeyer flasks with stoppers
5+ paper clips
3 petri dishes
liquid detergent
3 100 ml beakers
water
pepper shaker
wax paper or 3 pennies
3 plastic pipets
forceps
glycerin
isopropyl alcohol

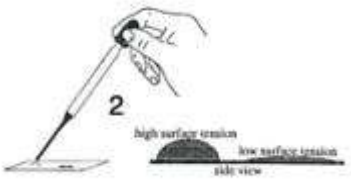
Pre-Lab: Predict the strength of the intermolecular forces of water, isopropyl alcohol and glycerol from weakest to strongest.

Procedure:

In this experiment you will be comparing three liquids, isopropyl alcohol, water and glycerol.

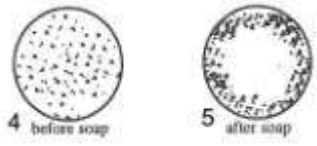
Part 1: Surface tension and vortex. When a liquid is swirled, a vortex is developed in which the surface level of the center of the liquid is substantially below the surface level of the perimeter. The greater the surface tension, the longer the vortex will remain after you have stopped swirling the container. On the front table there are three labeled flasks. One flask has isopropyl alcohol, one has water and one has glycerin. Make sure the stopper is on the flasks to prevent vapors from escaping into the room. Try to swirl each flask with the same intensity and record the time it takes for the vortex to disappear. Which liquid appears to have greater surface tension and greater intermolecular forces? Record your answer for Part 1.

Part 2: Surface tension and droplet shape: Using an eyedropper or pipet, transfer one drop of each fluid to a sheet of wax paper. The liquid with greater surface tension will maintain a higher profile and will not spread out as much as the one with lower surface tension. Which liquid appears to have the greater surface tension and greater intermolecular forces? Record your answer for Part 2.



Part 3: Surface tension and impenetrability: Liquids with strong intermolecular bonding will be less penetrable than those with weaker intermolecular bonding. Try to float a paper clip on water, isopropyl alcohol, and glycerol by gradually lowering a dry paper clip into each liquid on a cradle fashioned from another paper clip (Figure 3). It may be best to use a small beaker and some forceps for this procedure. Which liquid appears to have the greater surface tension and greater intermolecular forces? Record your answer for Part 3.

Part 4: Visualization of surface tension: The surface of a liquid with strong hydrogen bonding will exhibit great tension much like the head of a drum that has been pulled tight. If a drumstick ruptures the head of a drum, the sides recoil under the tension. In a similar manner, if a chemical ruptures the surface tension of a fluid, the "skin" of the liquid will recoil away from the point where the chemical was applied. Fill one Petri dish with water, another with isopropyl alcohol, and the third with glycerin. Sprinkle crushed pepper on the surface of both. The pepper will be more likely to float on the fluid with greater surface tension (Figure 4). Fill a pipette with liquid dish soap and hold over the center of each Petri dish until a drop of soap falls into the liquid. If the surface of the liquid is under tension, the pepper will recoil towards the sides immediately (see picture). Which liquid appears to have the greater surface tension and greater intermolecular forces? Record your conclusion for Part 4.



Part 5: Create models of the isopropyl alcohol (C_3H_8O), water, and glycerol ($C_3H_8O_3$) using the molecular modeling kits in the lab. Draw the Lewis Structure and 3-D picture of each molecule!

Data: Create your own data table

Analysis and Conclusions:

1) Did your predictions based on strength of intermolecular forces remain consistent with your **laboratory observations**? Support your statements for each of the three liquids with references to specific observations you made during the lab.

2) Which of the liquids you tested (isopropyl alcohol, water and glycerol), displayed the greatest surface tension (greatest intermolecular forces)? Use your observations as justification for your answer.

3) Which of the liquids you tested (isopropyl alcohol, water and glycerol), do you think will boil most easily? Why? Be specific. (You have to think about this one!)

4) You may have noticed mosquitoes, water striders, and other insects walking on the surface of a pond. Why don't they sink?

Post Lab Questions:

1. Predict whether the following molecules are polar or nonpolar. Justify your answer using VSEPR models. Draw the Lewis structures and explain your reasoning!

a) oxygen difluoride

b) methane, CH_4

c) carbon disulfide

d) fluoromethane, CH_3F

e) hydrogen peroxide

f) ammonia, NH_3

2. For the substances below, write the formula for the compound and place an X in the box for the force that you think the molecules will have.

Molecule	Formula	Dispersion	Dipole-Dipole	H-Bonds
Oxygen difluoride				
Methane				
Carbon disulfide				
Fluoromethane				
Hydrogen peroxide				
Ammonia				

3. When will hydrogen bonding occur? Give an example of a liquid other than water, in which this type of force is important.