Strength of Intermolecular Forces

Description: The strength of intermolecular forces among various substances is compared by observing rates of evaporation.

Materials:

- Water
- Pentane
- Hexanes
- Ether
- Liquid Nitrogen
- Helium
- Oxygen
- Carbon Dioxide
- Balloons

Procedure:

1. Have students draw the Lewis structures of the given liquids and predict which will have the strongest intermolecular forces (comparing dispersion, dipole-dipole, and hydrogen bonding). Compare water, ether, and liquid nitrogen by pouring them on the countertop and observing the rate of evaporation, faster rate = small IMF.

2. It is also useful to compare molecules with similar molecular weights/structures. Do this by comparing rates of evaporation on a chalkboard (if available). Compare water to ether by soaking two paper towels in each solvent and wiping the paper towel on the board. The same comparison can be done with pentane/hexanes.

3. The intermolecular forces of different gases can also be determined by filling balloons with He, O\(_2\), and CO\(_2\) and submerging them in N\(_2\) (l). He will remain as a gas, O\(_2\) as a liquid and CO\(_2\) as a solid.

Discussion: When observing the rates of evaporation for Procedure 1, students will observe that the strength of IMF increases as follows: N\(_2\) < Et\(_2\)O < H\(_2\)O. For Procedure 2, although Et\(_2\)O has a larger molecular mass, H\(_2\)O has stronger IMF due to hydrogen bonding. In the case of pentane vs. hexanes, the relative molecular weights dictate the observed rates of evaporation. In Procedure 3, although each sample is a gas at room temperature, the overall molecular motion can be slowed by cooling in liquid nitrogen, revealing the observed IMF strengths as: He < O\(_2\) < CO\(_2\).
Safety: Wear proper protective equipment including gloves and safety glasses when preparing and performing this demonstration. Take care not to perform demonstration near any ignition source. Wear insulated gloves when handling liquid nitrogen. Due to the volatile nature of some of the materials, perform this demonstration in a well ventilated area.

Disposal: No disposal is necessary since all materials used during this demonstration readily evaporate.

References:
