ScienceCube

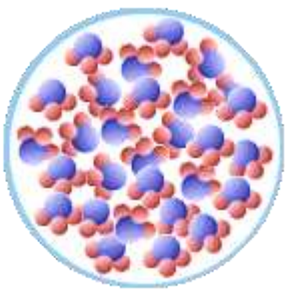
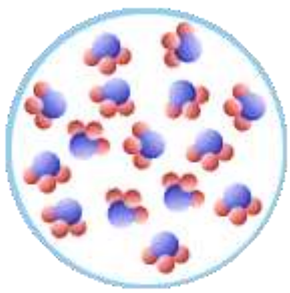
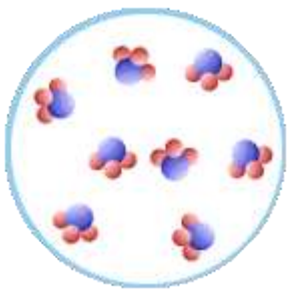
Intermolecular Forces and Evaporation

1. **Use latent heat of evaporation to infer the evaporation rate of substances.**
2. **Explain the difference in evaporation rates between substances in relation to intermolecular forces.**

Fundamental Concept

1. Molecular Motion

The phenomenon where molecules of a substance constantly move on their own without external force.

Solid	Liquid	Gas
		
Movement in place	Relatively free movement	Very active movement

2. Phenomena Resulting from Molecular Motion

(1) Evaporation

The phenomenon where molecules at the surface of a liquid move independently, breaking the intermolecular forces, and separate from the liquid surface to become gas and disperse into the air.

(2) Examples of Evaporation

- Salt is obtained by evaporating seawater in salt pans.
- Water evaporates from paint, leaving only the paint behind.
- Clothes dry as water evaporates from the washed clothes.
- Drought causes evaporation, leading to cracked ground.

(3) Conditions for Easy Evaporation

- Higher temperatures result in more active molecular motion, promoting evaporation.
- More wind causes molecules to disperse easily, enhancing evaporation.
- Drier conditions mean less water vapor in the air, facilitating evaporation.
- A larger surface area means more molecules can escape into the air, promoting evaporation.
- Weaker intermolecular forces make it easier for molecules to separate, enhancing evaporation.

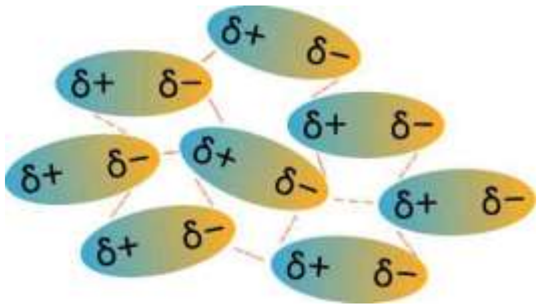
3. Intermolecular Forces

Intermolecular forces arise from electrostatic attraction due to partial charges.

Even neutral molecules with no overall charge can have partial charges if they have polar covalent bonds, forming dipoles. Even in non-polar covalent bonds, electrons can temporarily shift, creating temporary dipoles, known as induced dipoles.

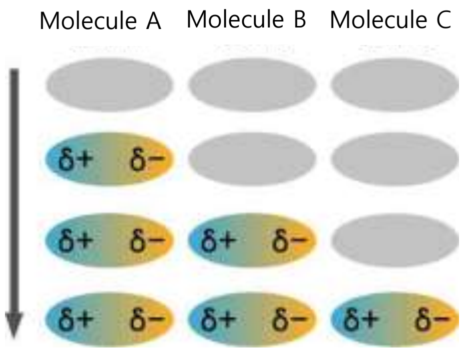
(1) Dipole-Dipole Forces

Dipole molecules have regions with partial positive (δ+) and partial negative (δ-) charges. These molecules arrange to maximize attraction between opposite charges and minimize repulsion between like charges. Dipole-dipole forces are stronger with larger dipole moments and shorter intermolecular distances.



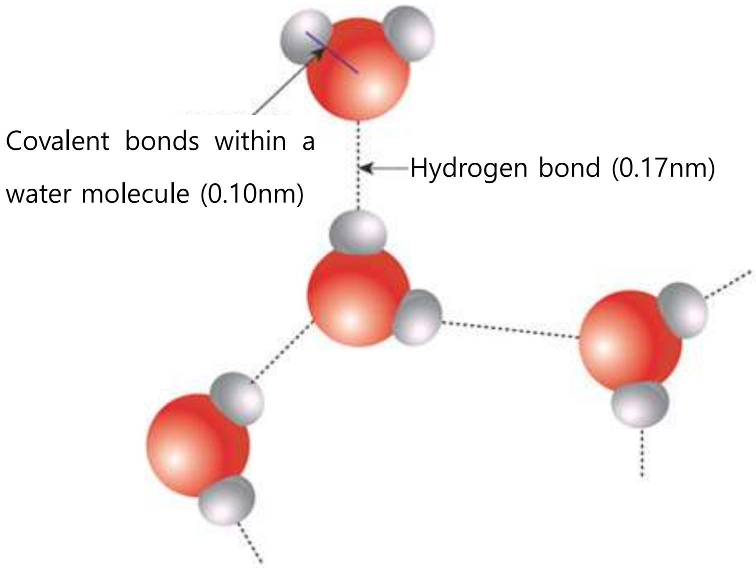
(2) Van der Waals Forces

In non-polar molecules, electrons are generally evenly distributed around nuclei but can temporarily shift, creating temporary dipoles. This phenomenon, known as polarization, induces dipoles that attract each other. The strength of this force depends on how easily molecules polarize..



(3) Hydrogen Bonding

Hydrogen atoms bonded to highly electronegative atoms like F, O, or N in a molecule can form abnormally strong attractions with lone pairs on other F, O, or N atoms in nearby molecules, known as hydrogen bonds. These bonds are about 1/10th the strength of covalent bonds, making them relatively strong among intermolecular forces.



Experiment

Materials Needed

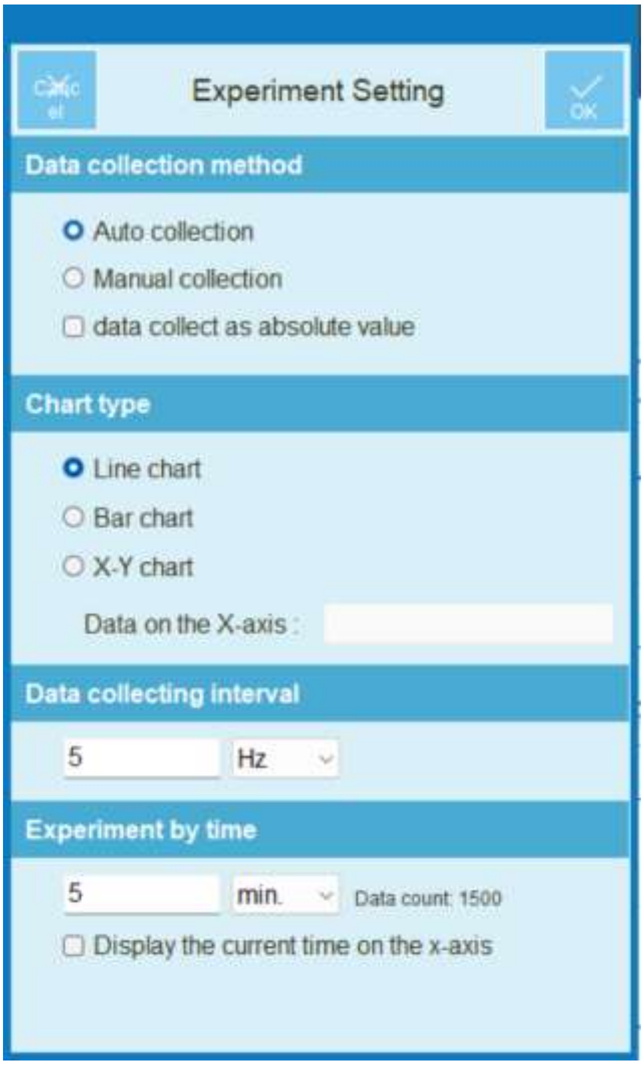
Interface, Science# program, Two temperature sensors, Two 50 mL beakers, Stand, Ethanol, Water, Buret clamp

Experiment Setup

1. Pour 30 mL each of water and ethanol into separate 50 mL beakers. (Let them reach room temperature before the experiment to ensure similar initial temperatures.)
2. Install the buret clamp on the stand and secure the two temperature sensors on each side.
3. Adjust the height of the buret clamp so that the sensors are submerged 3-5 cm into the liquids, without touching the bottom of the beakers.

Interface Setup

1.  Run the Science# program.
2. Connect the two temperature sensors to the interface.
3. Press  to set the experimental environment as shown below or press  for automatic setup.



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Data Collection

1. Raise the height of the buret clamp to lift the two temperature sensors out of the liquids
2. Press  to start data collection.

Data Analysis

Recording Data

1. Draw a graph showing the temperature changes over time for the two temperature sensors.

2. Record the temperature differences for the sensors submerged in ethanol and water in the table below.

Category	Initial Temperature (°C)	Final Temperature (°C)	Temperature Difference (°C)
Ethanol			
Water			

Data Application and Extension Activities

1. Describe how the temperature changes over time and explain the reason.

2. Identify the substance with the greatest temperature change and explain why.

3. Explain how intermolecular forces affect the evaporation rate of substances.

4. Think of ways to increase the temperature difference and describe them.

5. Predict the temperature changes if the experiment were conducted with saltwater or sugar water, and explain the reason