Intermolecular Forces

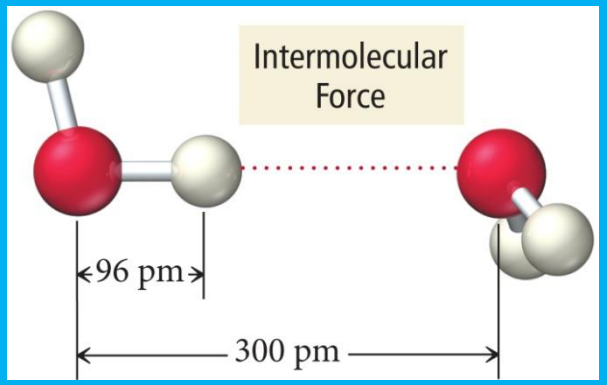
an introduction

Intermolecular Attractions

- The strength of the attractions between the particles of a substance determines its state.
- At room temperature, moderate to strong attractive forces result in materials being solids or liquids.
- The stronger the attractive forces are, the higher will be the boiling point of the liquid and the melting point of the solid.
  - Other factors also influence the melting point.

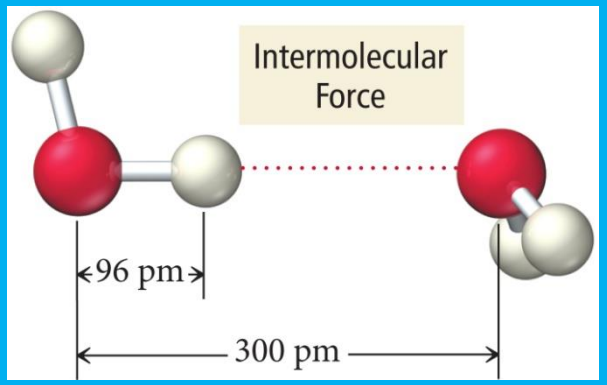
Why Are Molecules Attracted to Each Other?

- Intermolecular attractions are due to attractive forces between opposite charges.
  - + ion to − ion
  - + end of polar molecule to − end of polar molecule
    - H-bonding especially strong
  - Even nonpolar molecules will have temporary charges



Why Are Molecules Attracted to Each Other?

- **Larger charge = stronger attraction**
- **Longer distance = weaker attraction**
- However, these attractive forces are small relative to the bonding forces between atoms.
  - Generally smaller charges
  - Generally over much larger distances



Trends in the Strength of Intermolecular Attraction

- The stronger the attractions between the atoms or molecules, the more energy it will take to separate them.

Trends in the Strength of Intermolecular Attraction

- Boiling a liquid requires that we add enough energy to overcome all the attractions between the particles.
  - However, not breaking the covalent bonds

Trends in the Strength of Intermolecular Attraction

- **The higher the normal boiling point of the liquid, the stronger the intermolecular attractive forces.**
- Normal BP: vapor pressure = atmospheric pressure

Kinds of Attractive Forces

- Temporary polarity in the molecules due to unequal electron distribution leads to attractions called **London dispersion forces.**

Kinds of Attractive Forces

- Permanent polarity in the molecules due to their structure leads to attractive forces called **dipole–dipole attractions**.

Kinds of Attractive Forces

- An especially strong dipole–dipole attraction results when H is attached to an extremely electronegative atom [N,O,F]. These are called **hydrogen bonds.**

Relative Magnitudes of Forces

The types of bonding forces vary in their strength as measured by average bond energy.

Strongest

Weakest

Network Covalent bonds (400 kcal/mol)

Hydrogen bonding (12-16 kcal/mol)

Dipole-dipole interactions (2-0.5 kcal/mol)

London forces (less than 1 kcal/mol)

Practice

What type of IMF is in H_2O?

Hydrogen Bonding

Practice

What type of IMF is in Ammonia?

Hydrogen Bonding

Practice

What type of IMF is in HCl?

Dipole-Dipole

Practice

What type of IMF is in CO_2?

Londone Dispersion

Practice

What type of IMF is in CH_4?

London Dispersion

Practice

What type of IMF is in Hydrogen Sulfide?

Dipole-Dipole