Intermolecular Forces

Chapter 11

1

Why my sister never believes me anymore…

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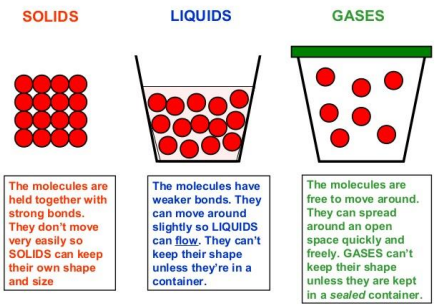
2

States of Matter



3

What are INTERmolecular (IMF) forces?

- Forces of attraction **between** different molecules
- Vary in strength but are usually weaker than bonds
- Not the same as chemical bonds (intramolecular force within molecules)

4

Why are IMFs important?

- Explain reasons for many physical properties of matter
  - States of matter, boiling/melting points, solubility, etc

Bonding type	Substance	Boiling Point
Non Polar Covalent	CH_4	-164 °C
Polar Covalent	NH_3	-33 °C
Ionic	NaCl	1413 °C
Metallic	Fe	2750 °C

5

Why are IMFs important?

- Example: Boiling Point –
  - Is there a relationship to bond type?
  - Is this the only factor?

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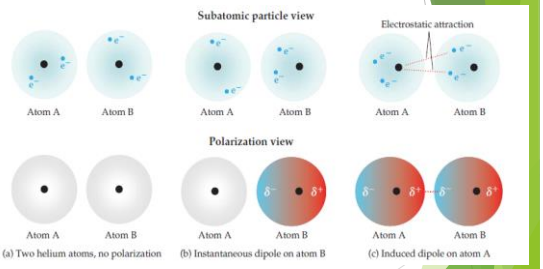
6

Types of IMFs—LDFs

- **<u>London Dispersion Force</u> (or just dispersion force):**
  - Weakest of the IMFs when compared on 1:1 basis
  - Form between **<u>all</u>** molecules but are the only IMF that forms between non-polar molecules and noble gases
  - Attraction between *instantaneous/momentary/temporary* dipoles between molecules

7

Types of IMFs—LDFs



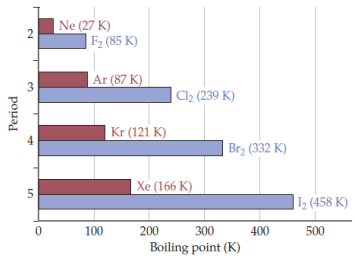
8

Types of IMFs—LDFs

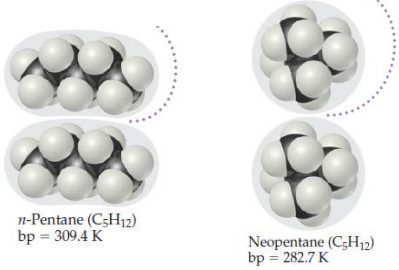
- Polarizability = degree to which the e- cloud can be distorted to form temporary dipoles
- More polarizable = stronger dispersion force
- Polarizability increases as the # of e- in an atom/molecule increases
- Larger mass of atoms/molecules = larger force
- Larger shape/surface area also = larger dispersion force

9

Relationship between BP and molecular weight

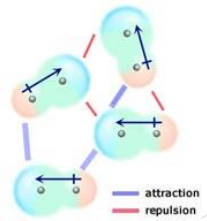


Relationship between BP and molecular shape

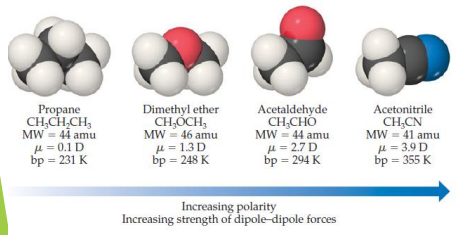


Types of IMFs—Dipole-dipole

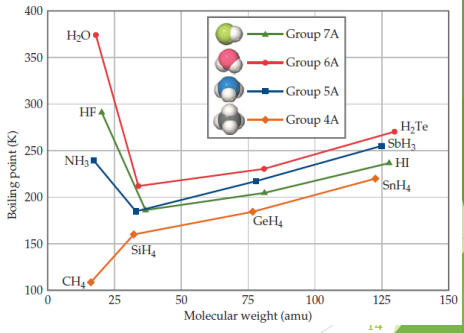
- **Dipole-Dipole Force:**
  - Opposite ends of POLAR molecules attract
  - More polar = larger force



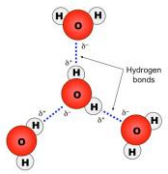
Polarity and dipole-dipole force strength



Why is the boiling point of SnH_4 higher than that of CH_4?



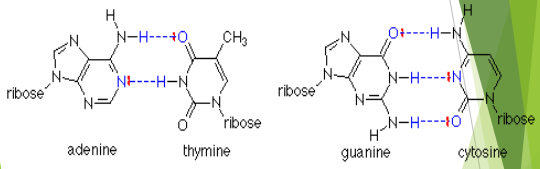
Types of IMFs—H-bonds



- **Hydrogen "Bonding":**
  - a particularly strong case of the dipole-dipole force
  - forms between a very (+) pole and a very (-) pole of two polar molecules
    - Due to large difference in electronegativity between bonded atoms
    - A hydrogen atom directly bound to a highly electronegative N, O, F is attracted to the NOF on another molecule

15

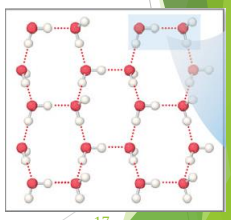
Example: H-bonding in DNA



16

Example: H-bonding in H_2O

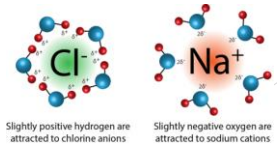
- Water is more dense as a liquid than as a solid (opposite of most substances)
- LIFE!



17

Types of IMFs—Ion-dipole

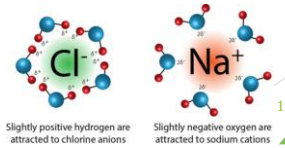
- **Ion-Dipole Force:**
  - Form between ions and polar molecules
    - Cations attracted to (-) pole
    - Anions attracted to positive (+) pole



18

Types of IMFs—Ion-dipole

- **Ion-Dipole Force:**
  - Stronger than dipole-dipole (even H-bonds)
  - Strength of attraction increases with increasing magnitude of:
    - ionic charge
    - dipole moment/polarity of molecule



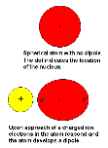
Slightly positive hydrogen are attracted to chlorine anions

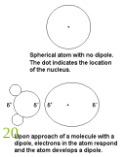
Slightly negative oxygen are attracted to sodium cations

19

Types of IMFs

- **Induced-Dipole Force:** Weak IMF that occurs when an ion or molecule with a dipole causes (induces) a dipole to form in an atom or molecule that does not otherwise have pole
  - **Ion-Induced Dipole Force**
  - **Dipole-Induced Dipole Forces**

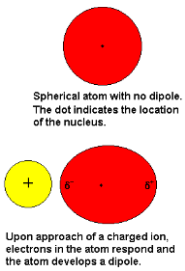




20

Types of IMFs

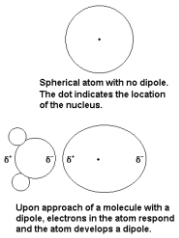
- **Ion-Induced Dipole Force**
  - Attraction that results from the approach of an ion that induces a dipole in an atom or non-polar molecule by disturbing the arrangement of electrons in the non-polar species



21

Types of IMFs

- **Dipole-Induced Dipole Forces**
  - Attraction that results from the approach of a polar molecule that induces a dipole in an atom or non-polar molecule by disturbing the arrangement of electrons in the non-polar species



22

Relative Strength of IMFs

STRONGEST

Ion-dipole
Hydrogen bond
Dipole-Dipole
Ion-Induced Dipole
Dipole – Induced Dipole
Dispersion Forces

WEAKEST

23