

Intermolecular Forces and Phase Changes

Objectives

1. To learn about dipole-dipole, hydrogen bonding and London dispersion forces
2. To understand the effect of intermolecular forces on the properties of liquids
3. To learn some of the important features of water
4. To learn about interactions among water molecules
5. To understand and use heat of fusion and heat of vaporization

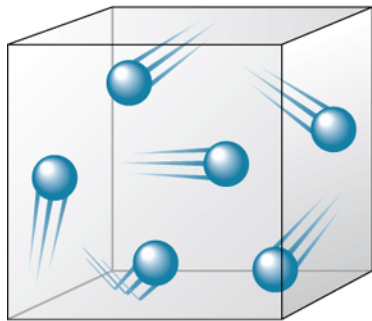
Intermolecular Forces and Phase Changes

A. Intermolecular Forces

Reviewing what we know

Gases

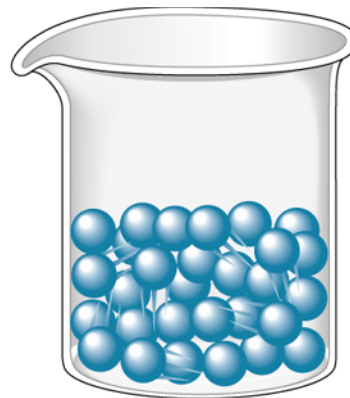
- Low density
- Highly compressible
- Fill container



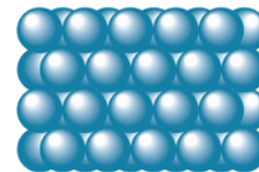
Gas

Solids

- High density
- Slightly compressible
- Rigid (keeps its shape)



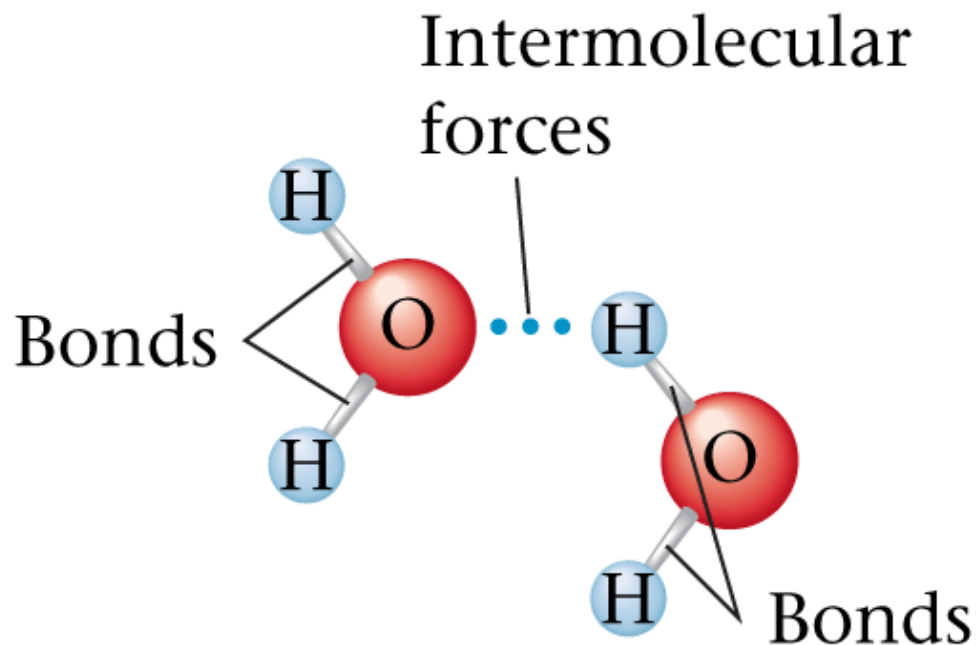
Liquid



Solid

Intermolecular Forces and Phase Changes

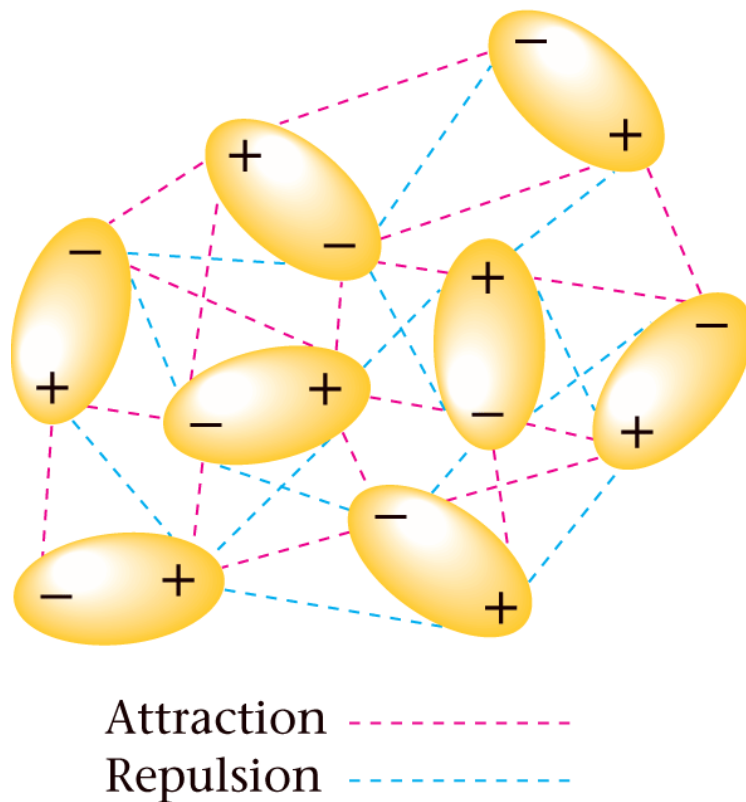
A. Intermolecular Forces



- **Intermolecular forces** – occur between molecules
- **Intramolecular forces** – occur inside the molecules

Intermolecular Forces and Phase Changes

A. Intermolecular Forces

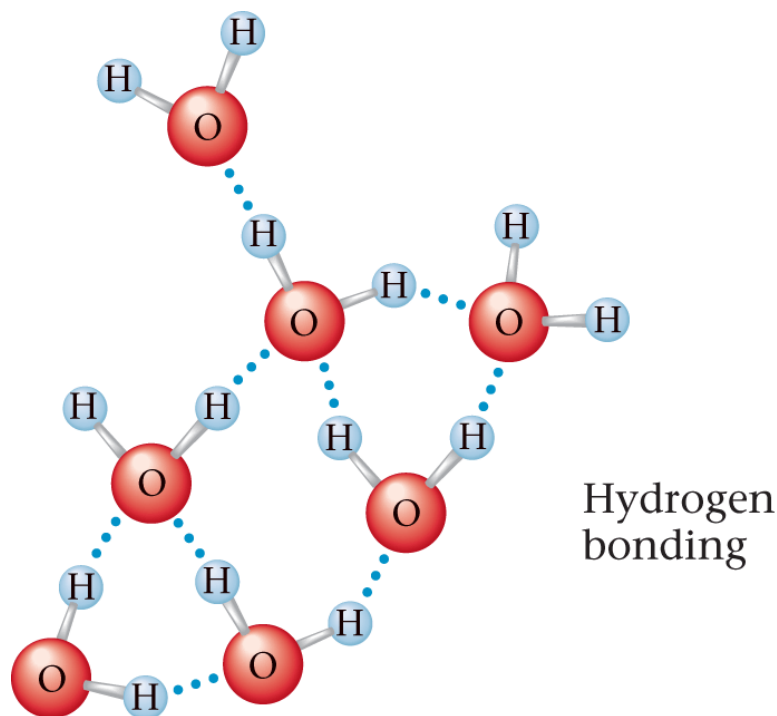


Dipole – dipole attraction

Intermolecular Forces and Phase Changes

A. Intermolecular Forces

Hydrogen Bonding



- Occurs between H and highly electronegative atom (for example N, O, F)

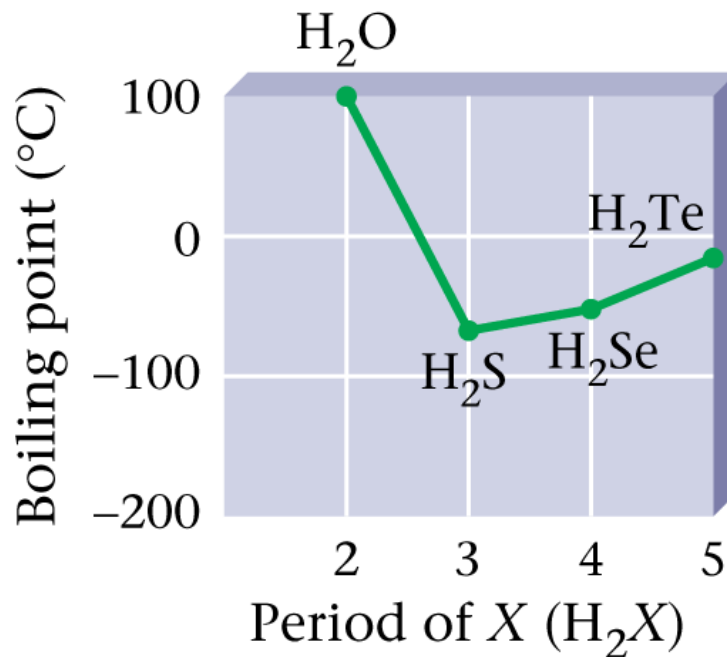
Section 14.1

Intermolecular Forces and Phase Changes

A. Intermolecular Forces

Hydrogen Bonding

- Affects physical properties
 - Boiling point



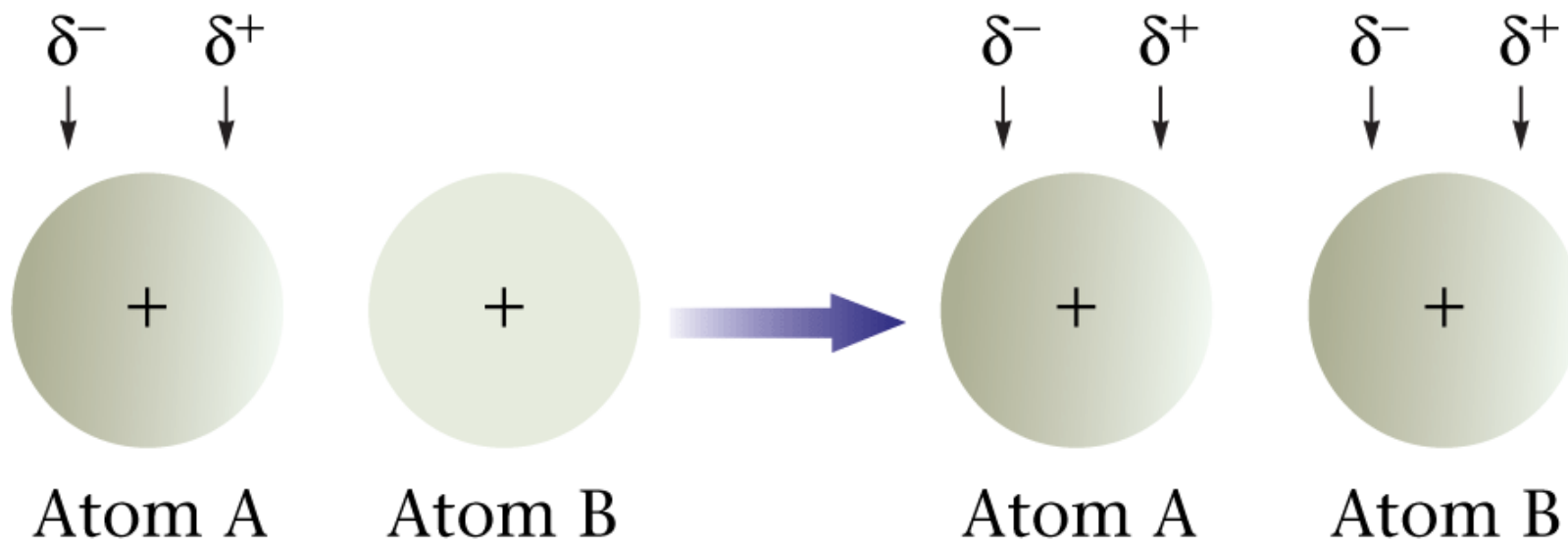
Intermolecular Forces and Phase Changes

A. Intermolecular Forces

London Dispersion Forces

- Formation of instantaneous dipoles

Instantaneous
dipole

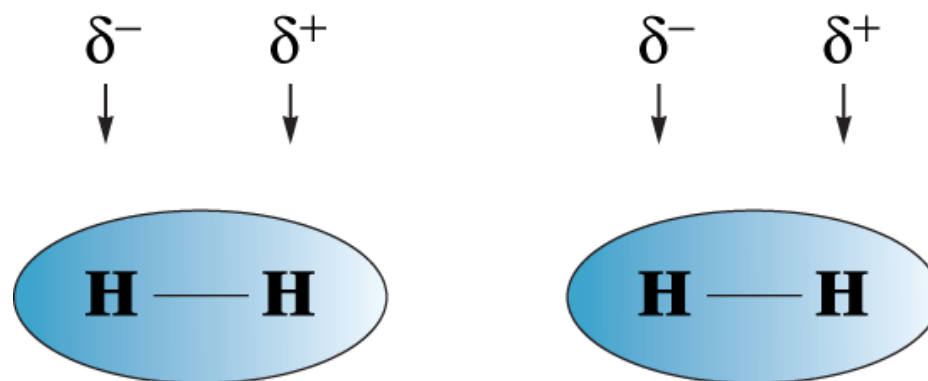


Intermolecular Forces and Phase Changes

A. Intermolecular Forces

London Dispersion Forces

- Nonpolar molecules



Molecule A

Molecule B

Instantaneous dipole on A
induces a dipole on B.

Intermolecular Forces and Phase Changes

A. Intermolecular Forces

London Dispersion Forces

- Become stronger as the sizes of atoms or molecules increase

Table 14.2

The Freezing Points of the Group 8 Elements

Element	Freezing Point (°C)
helium*	-272.0 (25 atm)
neon	-248.6
argon	-189.4
krypton	-157.3
xenon	-111.9

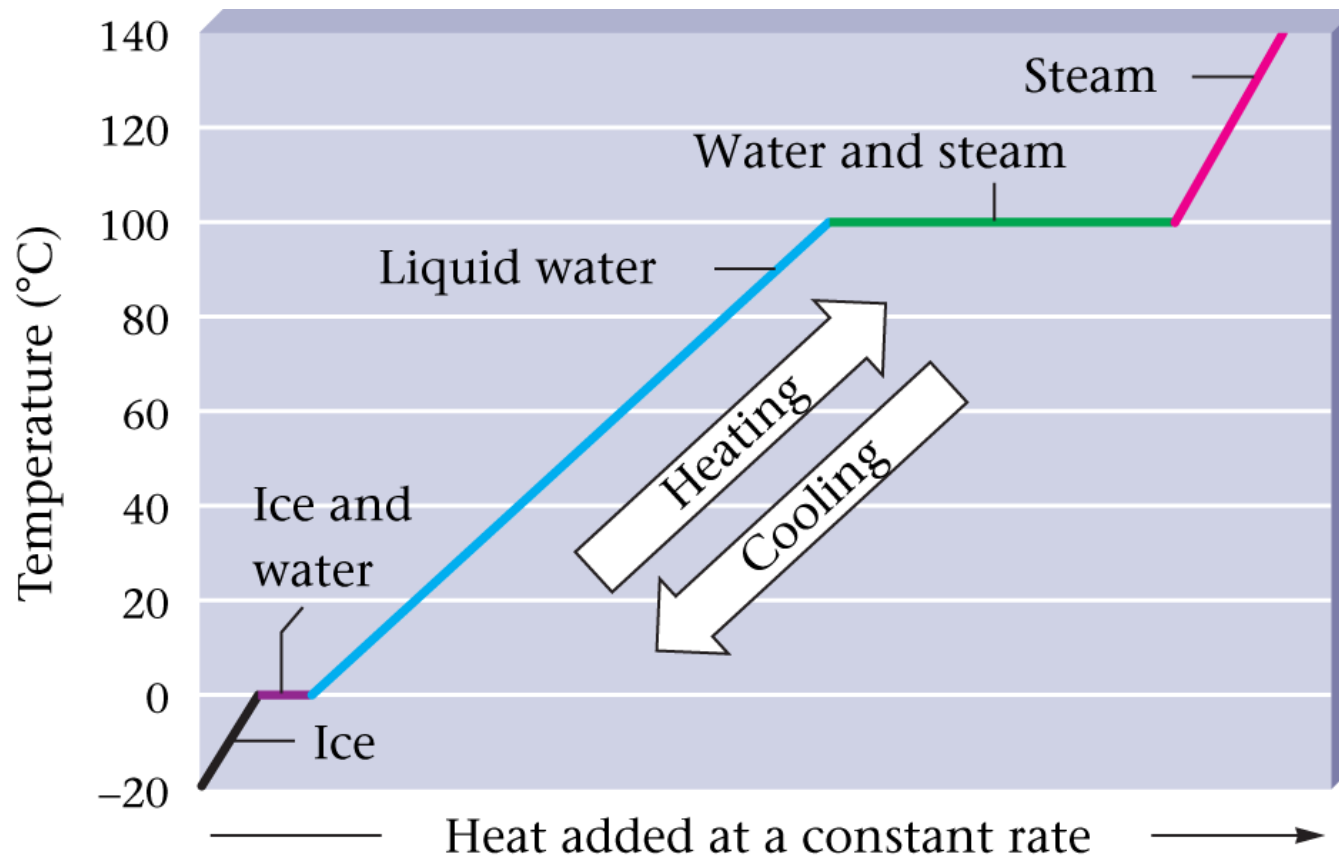
*Helium will not freeze unless the pressure is increased above 1 atm.

Section 14.1

Intermolecular Forces and Phase Changes

B. Water and Its Phase Changes

- Heating/cooling curve



Intermolecular Forces and Phase Changes

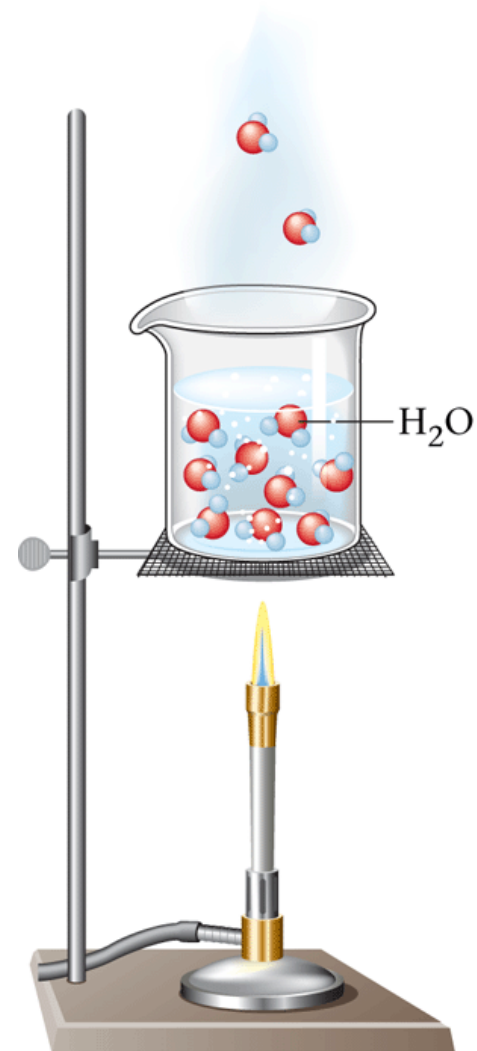
B. Water and Its Phase Changes

- Normal boiling point – at 1 atm = 100°C
- Normal freezing point – at 1 atm = 0°C
- Density
 - Liquid water = 1.00 g/mL
 - Ice = 0.917 g/mL

Intermolecular Forces and Phase Changes

C. Energy Requirements for the Changes of State

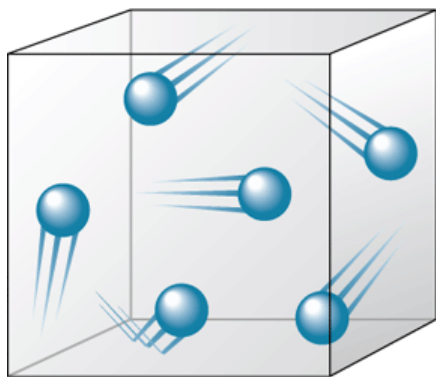
- Changes of state are physical changes
 - No chemical bonds are broken



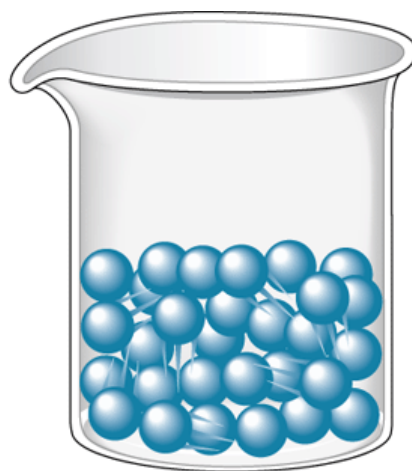
Intermolecular Forces and Phase Changes

C. Energy Requirements for the Changes of State

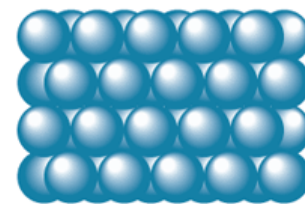
- **Molar heat of fusion** – energy required to melt 1 mol of a substance
- **Molar heat of vaporization** – energy required to change 1 mol of a liquid to its vapor



Gas



Liquid



Solid