CHEM 20B Week 3

Aidan Jan

January 22, 2024

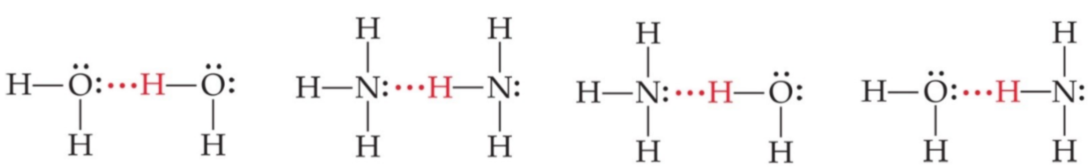
Intermolecular Forces (continued)

Repulsive Forces

- When two atoms or molecules are so close together that their respective core electrons repel each other, overwhelming the attractive forces.
- Very short range
- $\frac{1}{R^{12}}$

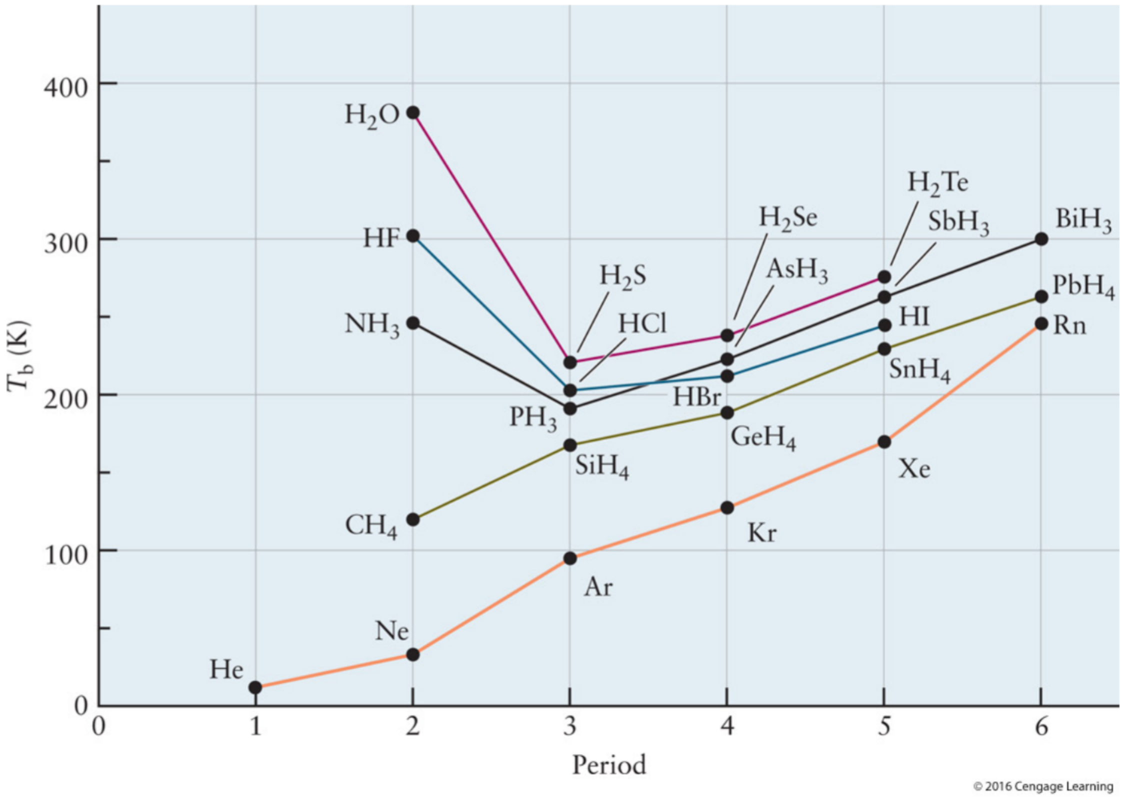
Hydrogen Bonding

- A special case of dipole-dipole
- Molecule with N-H, O-H, or F-H wtih polar molecule with lone pair on N, O, or F.
- N, O, and F are very electronegative and can almost steal electrons from hydrogen, leaving unshielded nucleus (p+), which can interact with lone pairs of N, O, or F.
- It is weaker than ionic and covalent bonds but stronger than any intermolecular force.



Intermolecular Forces in Liquids

Trends in the boiling points of hydrides of some main group elements and the noble gases



Review: Types of Intermolecular Forces

Ion-Ion Interaction	ion + ion
Ion-Dipole Interaction	ion + polar molecule
Hydrogen Bonding	Molecule with N-H, O-H, or F-H + polar molecule with lone pair on N, O, or F
Dipole-Dipole Interaction	polar + polar molecule
Ion-Induced Dipole Interaction	ion + nonpolar molecule
Dipole-Induced Dipole Interaction	polar molecule + nonpolar molecule
London Dispersion Forces	nonpolar molecule + nonpolar molecule

Steps for comparing properties of molecules

1. Identify the compound: ion vs. polar vs. nonpolar
2. Identify the types of intermolecular forces
3. If two molecules have the same types of intermolecular forces, compare **size (molecular weight)**, then shape

Intermolecular Forces Affect Many Physical Properties

- **Melting point:** solid → liquid
- **Boiling point:** liquid → gas
- **Vapor pressure:** pressure caused by molecules that escape from liquid, (to escape from liquid, need to break all intermolecular forces)

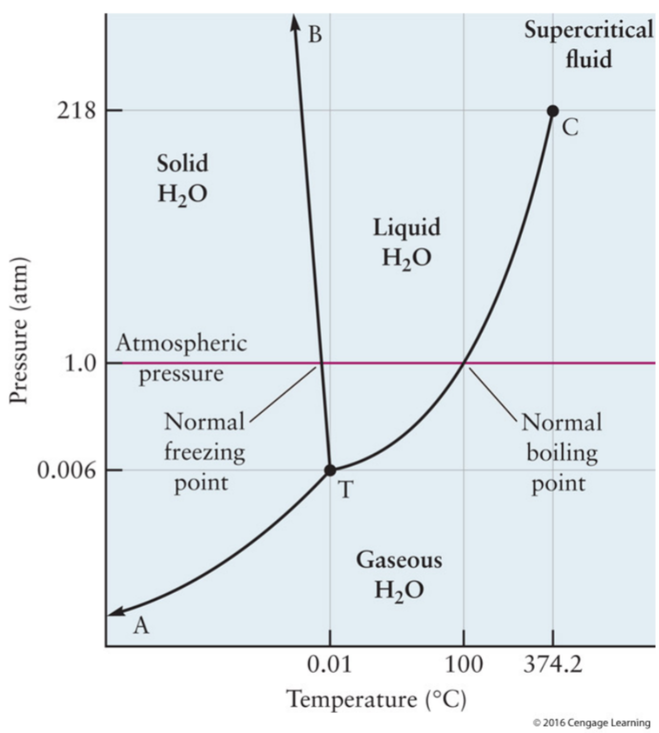
- Stronger intermolecular forces:
  - Higher boiling points (need higher temperature to break intermolecular forces)
  - Higher melting points (need higher temperature to break intermolecular forces)
  - Lower vapor pressure (harder for molecules to escape from liquid)

Phase Transition

- Boiling point: temperature in which the vapor pressure of a liquid equals the external pressure.
- Normal boiling point is the temperature at which the vapor pressure of the liquid equals 1 atm.

Phase Diagrams

- m.p. = normal melting point:
  - T(solid $\rightarrow$ liquid) at 1atm
- b.p. = normal boiling point:
  - T(liquid $\rightarrow$ gas) at 1atm, 373K (100° celsius)
- t.p. = triple point:
  - The pressure and temperature where the solid, liquid, and gas states coexist
  - (For H_2O: 0.01 Celsius, 0.006 atm)
- T_c, P_c: above which where there are no liquid or gas phase transitions, just gradual transition; called "supercritical region"
  -



Composition of Solutions

- Mole Fraction
$$X_1 = \frac{n_1}{n_1 + n_2}$$
- Concentration: number of moles per unit volume
  - SI Unit: $\mathrm{mol/m^3}$ (large for chemical work)
- Molarity:
$$molarity = \frac{moles\ solute}{liters\ solution} = molL^{-1} = M = molar$$
- Molality:
$$molality = \frac{moles\ solute}{kilograms\ solvent} = molkg^{-1}$$

Solutions

- Solute + Solvent
- Aqueous solution: solvent = water
- Species that dissolve in water:
  - Polar molecules:
    * Glucose $C_6H_{12}O_6$
    * Sucrose $C_{12}H_{22}O_{11}$
  - Ionic solic: NaCl(aq)
  - NaCl(aq) → Na^+(aq) + Cl^-(aq)

Precipitation Reaction

- A **precipitate** is an insoluble solid formed by a reaction in solution.
- Example:
  - Molecular Equation:
$$\mathrm{AgNO_3}(aq) + \mathrm{KCl}(aq) \longrightarrow \mathrm{AgCl}(s) + \mathrm{KNO_3}(aq)$$
  - Complete Ionic Equation:
$$\mathrm{Ag^+}(aq) + \mathrm{NO_3^-}(aq) + \mathrm{K^+}(aq) + \mathrm{Cl^-}(aq) \longrightarrow \mathrm{AgCl}(s) + \mathrm{K^+}(aq) + \mathrm{NO_3^-}(aq)$$
  - Net Ionic Equation:
$$\mathrm{Ag^+}(aq) + \mathrm{Cl^-}(aq) \longrightarrow \mathrm{AgCl}(s)$$