Chemistry 1212 w/ Dr. Suggs

Chapter 12

12.1: <u>States of Matter and Intermolecular Forces</u>

- Kinetic-Molecular theory of gas: assumes that gas molecules or atoms are widely separated and these particles can be considered to be independent of one another
- In ideal conditions, the properties of gas fall under the ideal gas law (PV=nRT)
    - P = pressure of gas
    - V = volume of gas
    - n = amount of gas (moles)
    - R = gas constant
    - T = gas temperature
- In real gasses, intermolecular forces (IMF) are at work; If these forces are strong enough, they cause the gas to condense to a liquid and eventually a solid
- There is a large increase in volume when converting liquid to a gas, but no dramatic change in volume occurs when converting a liquid to a solid
    - It can therefore be assumed that the molecules in liquid are about as closely packed as those in solids
- How do IMF's influence chemistry?
    1. They are directly related to melting point/boiling point
    2. They are important in determining the solubility of solids, gasses, and liquids in different solvents
    3. They help determine the structure of molecules
- IMF's between molecules are electrostatic
    1. Dipole-dipole forces: between molecules with permanent dipoles (molecule with permanent partial charges)
    2. Dipole-induced dipole forces: polar molecules and nonpolar ones

3. Induced dipole-induced dipole forces: nonpolar molecules (also called London forces)

12.2: <u>Interactions between Ions and Molecules with a Permanent Dipole</u>

- Ion-dipole forces: attraction between a positive or negative ion and a polar molecule
- Ion-ion forces are the most strong
- Coulomb's Law: (a way to evaluate ion-dipole attractions) states that the force of attraction between two charged objects depends on the product of their charges divided by the square of the distance between them
    - The closer the molecules are, the greater the attraction
    - The higher the ion charge, the stronger the attraction
    - The greater the magnitude of the dipole, the stronger the attraction
- Example of the interaction between an ion and a polar molecule:
    - Hydration of ions (enthalpy of solvation/enthalpy of hydration)
    - Has a substantial enthalpy change, but it cannot be measured directly
    - The enthalpy of hydration depends on the charge of the ion and 1/d (d = distance between center of ion and oppositely charged pole of dipole)

12.3: <u>Interactions between Molecules with a Dipole</u>
Dipole-Dipole Forces

- Dipole-Dipole Interaction: when one polar molecule interacts with another dipole molecule (either different of the same kind) the positive end of one molecule will be attracted to the negative end of the other molecule
    - These attractions influence the evaporation of a liquid and the condensation of gas (each requires an energy change

        - Evaporation requires the input of energy (enthalpy of vaporization) this change has a positive enthalpy; so this process is endothermic
        - The enthalpy change for condensation is the opposite (exothermic) so it has a negative enthalpy
- The greater the force of attraction between the molecules, the greater the energy that must be applied to separate them
    - So we would expect polar compounds a higher value of enthalpy of vaporization than nonpolar compounds with similar molar masses
- Boiling Point
    - As the temperature of a liquid is raised, its molecules gain kinetic energy
    - Once enough kinetic energy is attained (at the liquid's boiling point) the molecules have sufficient kinetic energy to break the IMF's between themselves and neighboring molecules
    - For molecules of similar molar mass, the greater the polarity of the molecule, the higher the boiling point
- Solubility
    - "Like-dissolves-like" meaning polar molecules are likely to dissolve in polar solvents, and nonpolar molecules are likely to dissolve in nonpolar solvents
    - Water is a polar solvent

Hydrogen Bonding

- In general, the boiling point of hydrogen compounds (i.e. CH4, SiH4…etc.) increase with increasing molar mass
- There are a few exceptions to this rule:
    - Hydrogen compounds containing Nitrogen (N), Fluorine (F), or Oxygen (O), have much greater